



Adaptive Engagement of Older Adults' Fitness through Gamification

by

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“We don't stop playing because we grow old; we grow old because we stop playing”

George Bernard Shaw

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*“I have no special talents. I am only passionately
curious.”*

Albert Einstein

Abstract

Older adults are often not physically active because they lack motivation, time, and/or physical ability. Not only does this impact the life of older adults, but it also affects society as a whole, because the cost of healthcare attached to maintaining the health of older adults is continually rising. This thesis addresses the problem by investigating the disenchantment of older adults with physical activity (PA), reasons for their lack of participation in PA, and contributes motivational affordances for PA. This thesis makes three important contributions to human-computer interaction: a) the development of adaptive engagement guidelines for PA technology for older adults. b) the Exercise Motivation Technology Framework (EMTF) - a framework to aid in the design and development of PA technology for older adults, and c) the Kaleidoscope of Effective Gamification (KEG) - a design and analysis tool for helping designers design and develop gamified apps.

These contributions were achieved through a phased investigative approach. The analysis of preliminary studies (Phase 1) resulted in the development of the EMTF for older adults PA technology. A survey study (Phase 2) on the preferences of motivational affordances for PA across different age groups suggested that ‘health pressures’ and ‘ill-health avoidance’ were significant exercise motives for PA in different age groups. Age-differentiated guidelines from Phase 2 were used to develop and evaluate Spirit50 (Phase 3), a gamified technology artifact, specifically developed under my supervision for adults over 50 years of age. Phase 4 was a synchronous, three-condition (gamified, non-gamified, and control groups) experimental study over an eight-week period with a total of 30 participants. Expert evaluation (Phase 5) to review technology facilitation of PA using the Spirit50 app also pointed to the usefulness and the applicability of gamification as a behaviour change technology for delivering PA solutions for older adults.

The findings of this thesis contribute to understanding PA motivation among older adults on a granular level from a technology facilitation standpoint using gamification strategies. The EMTF model helped to design PA technology by combining desirability, customization, and motivational affordances for older adults. Finally, this thesis contributes to tailoring and

personalizing of adaptive engagement strategies using specific gamification elements like goals supported by challenges, selection of quests based on ability, progressive feedback, and rewards validating performance and efforts as potential ways to deliver age-centric PA technology for older adults

Keywords: gamification; motivation; motivational affordances; physical activity; user experience design; assistive technologies

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Peer-Reviewed Publications

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2. Dennis L. Kappen, Pejman Mirza-Babaei and Lennart E. Nacke. 2018. Older Adults' Physical Activity Gamification: An Eight-Week Study. In *Proceedings of the Annual Hawaii International Conference on System Sciences-51*.
3. Dennis L. Kappen, Pejman Mirza-Babaei and Lennart E. Nacke. Gamification through the Application of Motivational Affordances for Physical Activity Technology. In *Proc. of CHI PLAY '17*. 5-18
4. Dennis L. Kappen, Lennart E. Nacke, Kathrin M. Gerling, and Lia E. Tsotsos. 2016. Design Strategies for Gamified Physical Activity Applications for Older Adults. In *Proceedings of the Annual Hawaii International Conference on System Sciences-49*. 1309–18. DOI: <https://doi.org/10.1109/HICSS.2016.166>
5. Dennis L. Kappen. 2015. Adaptive Engagement of Older Adults' Fitness through Gamification. In *Proc. of CHI PLAY 2015 (Doctoral Consortium)*. 141-148
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7. Dennis L. Kappen, John Gregory, Daniel Stepchenko, Rina R. Wehbe, and Lennart E. Nacke. 2013. Exploring Social Interaction in Co-located multiplayer games. In *CHI '13 Extended Abstracts on Human Factors in Computing Systems*. CHI EA '13. New York, NY, USA: ACM, 1119–1124. DOI: <https://doi.org/10.1145/2468356.2468556>
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7. Dennis L Kappen and Rita Orji. 2017. Gamified and Persuasive Agents for Health Behavior Change Systems as and Wellness. *XRDS*, 52–55. <https://doi.org/10.1145/3123750>

Statement of Originality and Co-Authorship

This research investigation was carried out under the supervision of Dr. Lennart E. Nacke and Dr. Pejman Mirza-Babaei. I am the primary contributor to this dissertation except for the interview data that was used in Phase 1: Preliminary Studies (Section 5.3.1.1). These data were provided by the Center of Elder Research (CER), Sheridan College, Oakville, under a memorandum of understanding for an NSERC Grant gamification project. However, I analysed these data based on the methods outlined in the data analysis section of Phase 1 (Chapter 5) of this dissertation. Materials and key results of this dissertation have previously appeared in peer-reviewed journal and conference publications.

The following are details of materials used in the dissertation from publications.

- **Chapter 1 and 2** (Publication #1): Materials in this dissertation from the introduction and literature review section is under review for publication in the *International Journal of Human Computer Interaction Journal* publication after the submission of my dissertation. I was the primary author and conducted the research under the supervision of Dr. Lennart E. Nacke and Dr. Pejman Mirza-Babaei.
- **Chapter 3** (Publication #9): Materials in this chapter was published in the *Proceedings of the First International Conference on Gameful Design, Research, and Applications - Gamification '13* (Kappen & Nacke, 2013). I was the primary author and conducted the research under the supervision of Dr. Lennart E. Nacke. I have included an ACM License to use and reproduce in dissertation statement from *RightsLink: Copyright Clearance Centre* (Appendix 13.13.1).
- **Chapter 5** (Publication #4): Materials in this chapter was published at the *IEEE Proceedings of the Annual Hawaii International Conference on System Sciences-49* conference (Kappen, Nacke, Gerling, & Tsotsos, 2016). I was the first author and major contributor to the paper where I framed the analysis and overall content of this publication. Dr. Kathrin Gerling, third author on the paper helped with refining the discussion section. Dr. Lia Tsotsos helped with reviewing the *Participants and Procedure*, and the *Interview Protocol* paragraphs of the paper because the interviews were conducted at CER. I conducted the research under the supervision of Dr. Lennart E.

Nacke. I have included an IEEE License to use and reproduce in dissertation statement from *RightsLink: Copyright Clearance Centre* (Appendix 13.13.2).

- **Chapter 6** (Publication #3): Materials in this dissertation from the introduction and literature review section was selected for publication in the *Proceedings of CHIPLAY 2017*, after the submission of my dissertation. I was the primary author and conducted the research under the supervision of Dr. Lennart E. Nacke and Dr. Pejman Mirza-Babaei. I have included an ACM License to use and reproduce in dissertation statement from *RightsLink: Copyright Clearance Centre* (Appendix 13.13.3).
- **Chapter 8** (Publication #2): Materials in this dissertation from this chapter was selected for publication at the *IEEE Proceedings of the Annual Hawaii International Conference on System Sciences-51 2018*, after the submission of my dissertation. I was the primary author and conducted the research under the supervision of Dr. Lennart E. Nacke and Dr. Pejman Mirza-Babaei. I have included an IEEE License to use and reproduce in dissertation statement from *RightsLink: Copyright Clearance Centre* (Appendix 13.13.4).
- **Publication #4**: I was the major contributor to the paper on co-located game audiences (Kappen et al., 2014) where I conducted the study design and wrote the paper. Jens Johannsmeier, a visiting undergraduate student who collaborated in the statistical analysis. Undergraduate students, Daniel Buckstein and James Robb helped me with coordinating the study under my supervision. I was the primary author and conducted the research under the supervision of Dr. Lennart E. Nacke.
- **Publication #5**: This paper was on exploring social interaction in co-located spaces (Kappen, Gregory, Stepchenko, Wehbe, & Nacke, 2013). I contributed to framing and writing the paper. John Gregory and Daniel Stepchenko were students who were involved in the design and development of the MagicDuel game. Rina Wehbe was a master's student who reviewed the paper. I was the primary author and conducted the research under the supervision of Dr. Lennart E. Nacke.

Definitions

Terminology	Definition	Reference
Adaptive	The term <i>adaptive</i> may have multiple meanings in computer science, in the context of this PhD research, <i>adaptive</i> indicates the ability of the online application to be customized to users' goals, motivations, barriers, and current health.	(Geurts et al., 2011)(Smeddinck, Siegel, & Herrlich, 2013)
Adaptive Engagement	Tailoring of older adults' engagement through customization and personalization of motivational affordances for PA	(Kappen, Mirza-Babaei, & Nacke, 2018)
Effective Gamification	Effective gamification should influence human behaviour through engaging experiences, using game design principles in decision-making applications and services not related to gaming	(Kappen & Nacke, 2013)
Extrinsic Motivations	Behaviour of doing an activity to attain some <i>separable outcome</i> .	(R. M. Ryan & Deci, 2000a)
Fitness Gamification	Fitness gamification is the use of game design principles to influence motivated participation in physical activity exercise routines using behaviour change theories.	(Section 1.5)
Intrinsic Motivations	Behaviour of doing an activity for its inherent satisfactions (enjoyment, interest) without a <i>separable consequence</i> .	(R. M. Ryan & Deci, 2000a)
Motivational Affordances	Motivational affordances are game elements which help foster intrinsic and extrinsic motives. This term is used interchangeably with gamification.	(Juho Hamari, Koivisto, & Sarsa, 2014)

Abbreviations

Terminology	Definition	Reference
CET	Cognitive Evaluation Theory	(R. M. Ryan & Deci, 2000a)
CER	Centre for Elder Research	Sheridan College, Oshawa, Ontario, Canada
CHAMPS	Community Healthy Activities Model Program for Seniors	(Stewart et al., 2007)
CT	Computer-Tailored	
DSR	Design Science Research	(Vaishnavi & Kuechler, 2013)
EMI	Exercise Motivations Inventory	(Markland, 1999)
EMI-2	Exercise Motivations Inventory-2	(Markland & Ingledew, 1997)
EMTF	Exercise Motivation Technology Framework	
FBM	Fogg Behaviour Model	(Fogg, 2009)
GTM	Grounded Theory Method	(Charmaz, 2006; Corbin & Strauss, 2015)
HEG	Heuristics Evaluation for Gameful design	(Tondello, Kappen, Mekler, Ganaba, & Nacke, 2016)
HBM	Health Belief Model	(Janz & Becker, 1984) (Glanz, 2015)
IMI	Intrinsic Motivation Inventory	(McAuley, Duncan, & Tammen, 1989; Mekler, Bopp, Tuch, & Opwis, 2014)
KEG	Kaleidoscope of Effective Gamification	(Kappen & Nacke, 2013)
MBL	Motivated Behaviour Layer	(Kappen & Nacke, 2013)
OA	Older Adult	
PA	Physical Activity	
PASE	Physical Activity Scale for the Elderly	(Bolszak, Casartelli, Impellizzeri, & Maffiuletti, 2014)
PBC	Perceived Behavioural Control	(Ajzen, 2015; Motalebi, Iranagh, Abdollahi, & Lim, 2014).
PNSE	Psychological Need Satisfaction in Exercise	(Wilson, Rogers, Rodgers, & Wild, 2006)
PT	Physical Trainer	
QCA	Qualitative Content Analysis	(Klaus Krippendorff, 2013; Schreier, 2012)
QoL	Quality of Life	
RCT	Randomized Controlled Trial	
RPE	Rating of Perceived Exertion	(Borg, 1982)
SCT	Social Cognitive Theory	(Bandura, 2002)
SDT	Self-Determination Theory	(Deci, 2008)(R. M. Ryan & Deci, 2000a)

SQUASH	Short Questionnaire to Assess Health-Enhancing Physical Activity	(van Stralen, de Vries, Mudde, Bolman, & Lechner, 2009)
TPB	Theory of Planned Behaviour	(Ajzen, 2015; Motalebi et al., 2014).
TTM	Trans-theoretical Model	(Motl, 2014)

Chapter 1

1 Introduction

As the general population in Western countries shifts towards an aging demographic, older adults are trying to lead healthy lifestyles (Barwais, Cuddihy, & Tomson, 2013) while maintaining physical and mental wellness. Information technology has evolved over time to enable the creation of fitness apps (Lister, West, Cannon, Sax, & Brodegard, 2014) and wearable technologies to help adults participate in physical activity (PA) with health benefits (Blobel, Pharow, Sousa, & McCallum, 2012; Shin & Jarrahi, 2014). Participation in recreational activities such as playing digital games or technology-supported exercising contributes to improving the quality of life (QoL) for older adults' (Marston, 2013). Video games, as playful technology applications, provide entertainment and disport (Gamberini et al., 1999; Smeddinck et al., 2013) for this demographic. Benefits of playing range from focused attention (Hwang, Hong, Jong, Lee, & Chang, 2009), increased gameplay engagement (Belchior, Marsiske, Sisco, Yam, & Mann, 2012), improvement in range of motion (ROM) (Bobeth, Schmehl, Kruijff, Deutsch, & Tscheligi, 2012), mental stimulation (Ijsselsteijn, Nap, de Kort, & Poels, 2007; Marston, 2013; Siriaraya, Ang, & Bobrowicz, 2012), to social connectedness (Pedell, Vetere, Kulik, Ozanne, & Gruner, 2010; Waycott et al., 2013) among their peer groups.

Commercial games such as the Nintendo Wii Fit or Microsoft Kinect Xbox Zumba Fitness are designed with the general population in mind as opposed to the needs of older adults. However, concepts of game design (e.g., actions, challenges, and achievements) can be applied to the daily activities of older adults to make their lives more engaging. Game-based technology (Gamberini et al., 2008) that makes mundane tasks such as: doing daily chores, managing tasks and remembering to take medications to mention a few, more interesting and playful by appealing to our emotions is becoming more popular. This is also known as gamification, which is the process of using game design principles (Kappen & Nacke, 2013) in non-game contexts (Deterding, Dixon, Khaled, & Nacke, 2011; Deterding, Sicart, Nacke, O'Hara, & Dixon, 2011). Research suggests that gamified fitness applications are one way to engage people in regular PA (Lister et al., 2014). However, not all older adults engage with fitness in the same way (Schutzer &

Graves, 2004a), and they often face more substantial cognitive and physical challenges compared to a younger population.

1.1 Research Problem

Older adults are often not physically active because they lack motivation, time, and physical ability (M. Dacey, Baltzell, & Zaichkowsky, 2008; M. L. Dacey & Newcomer, 2005). This poses a problem to a society that is aging fast because disengagement with PA bears health risks for older adults. Not only does this impact the life of older adults, but it also affects society as a whole, because the cost of healthcare attached to maintaining the health of older adults is continually rising. Older adults struggle to develop adequate exercise habits to maintain their health (Bethancourt, Rosenberg, Beatty, & Arterburn, 2014) and face the challenges of decreasing strength (Gerling, Schulte, Smeddinck, & Masuch, 2012), potential diminished mental capacity (Evenson, Buchner, & Morland, 2012), and social isolation (Porter, Fischer, & Johnson, 2011). Often, these challenges result in the adoption of a sedentary lifestyle (Chase, 2013). This PhD thesis investigates a conceptual understanding of the relationship between doing PA and being motivated to do PA facilitated by technology, as well as its importance in enhancing the quality of life of older adults.

1.2 Motivation

Cognitive and physical challenges faced by older adults poses barriers and limitations for them to participate in PA (Bethancourt et al., 2014; Czaja, S. J, Lee, 2007). These barriers and limitations can be mitigated through the use of technologies that encourage physical activity (Consolvo, Everitt, Smith, & Landay, 2006). Research emphasizes the positive aspects of gaming and technology for seniors [107]. In comparison to the older adult demographic, most usability studies have been conducted with younger adults (Smith, Sherrington, Studenski, Schoene, & Lord, 2009). However, investigating the limitations and abilities of older adults helped develop interaction guidelines for designing movement-based digital exercise games that encourage PA for this demographic (Hwang et al., 2009). The current fitness activity routines of older adults consist of interactions with a fitness trainer, engaging in-group fitness activities, independently pursuing fitness routines within their homes, or exercising in a gym (Boschman, 2010; Nied & Franklin, 2002; Services, 1996). Additionally, a few other activities that older adults participated

in were walking, hiking, trekking, dancing, aerobics or swimming to mention a few (Evenson et al., 2012; Markland & Ingledew, 1997).

Research has indicated the advantages of games (Payne, Moxley, & MacDonald, 2015), gamification (Edwards et al., 2016) and persuasive technology (Yoganathan, 2015) to motivate adults for PA. The increase in the popularity of health and fitness apps provides users with the ability to track their activities, sleep patterns and caloric intake on a daily basis (Lister et al., 2014). While technology artifacts like Fitbit (“FitBit,” 2015), Nike+ FuelBand (“Nike+ FuelBand,” 2014), and Google Fit (“Google Fit,” 2015) have enabled people to track their PA, it is important to question the effectiveness of these tools and to develop engaging technologies based on the factors that motivate older adults’ to engage in PA.

1.2.1 Older Adults and Social Interaction

Games have always been a social activity. Playing games affords and often necessitates spending time with others, and helps build personal connections between individuals. Games foster and enhance social connectedness, mutual dependencies, collaboration, community living, and social interaction (J Hamari & Koivisto, 2013; Mubin, Shahid, & Mahmud, 2008; Vargheese, Sripada, Masthoff, & Oren, 2016; Xu et al., 2008). Prior research (Brauner, Valdez, Schroeder, & Ziefle, 2013) has been conducted on the benefits of gaming activities and how older adults use game technology (Bird, Clark, Millar, Whetton, & Smith, 2015). This research focused predominantly on the relevance of gaming and its applicability in rehabilitation, physical and cognitive training, leisure and entertainment, and adult learning. However, little research has been done to investigate the motivations of older adults and social interaction in PA afforded through a digital game-based environment.

1.2.2 Older Adults and Physical Activity

While older adults participate in aerobic activity classes, dancing, yard work or gardening, swimming and water aerobics (Elsawy & Higgins, 2010), or even Tai Chi (Pigford, 2010), cognitive changes and increasing physical challenges associated with aging reduces their range of movements and their ability to participate in video game exercising (Lin, Mamykina, Lindtner, Delajoux, & Strub, 2006). Playful applications, such as motion-based video games, hold the promise of providing accessible PA for older adults (Gerling, Livingston, Nacke, &

Mandryk, 2012a). Prior research has demonstrated the potential benefits of these game applications for an aging demographic on a physical level (Schutzer & Graves, 2004a) and their emotional well-being (Jung, Li, Janissa, Gladys, & Lee, 2009b). A better understanding of how interactive technologies can meet the needs of older adults will help us create technologies that are meaningful in the context of their lives. This is a crucial step to enable older adults to leverage the benefits of playful technologies. It helps them establish and maintain healthy lifestyles and PA routines, which are vital to their well-being at an advanced age.

A study about the effectiveness of PA gamification among adults between the ages of 23 and 54 indicated that continuous measurement, virtual rewards and social comparison helped promote walking (Zuckerman & Gal-Oz, 2014). Gamification strategies incorporating rewards-based activity programs indicated meeting of daily recommended activity targets (van Mierlo, Hyatt, Ching, Fournier, & Dembo, 2016). Incorporating important elements of behavioural theory, combined with gamification has helped individuals to have a different perspective towards health and wellness goals with PA (Lister et al., 2014). Advantages of monitoring health goals such as *exercise, nutrition weight control, medication adherence and hygiene* contributed to healthy behaviour (Pereira, Duarte, Rebelo, & Noriega, 2014).

On a personal note, as an industrial designer, I was involved in designing physical products for older adults to help improve their lifestyle. My interactions with this demographic exposed me to negative consequences of aging caused by loneliness and sedentary lifestyles. This further inspired me to research the application of gaming technology to motivate this demographic in experiencing enjoyment through play.

1.3 Research Goals and Approach

The primary question driving this research was:

How can gamification elements be used to foster the intrinsic and extrinsic motivations for physical activity and daily exercise routines among older adults? How can customization of gamification elements be done for PA applications for this demographic?

This thesis addresses the problem by investigating the disenchantment of older adults with PA, reasons for lack of engagement and motivation with PA, and contributes to the potential increase in PA motivation through the use of motivational affordances. Motivational affordances *are game elements which help foster intrinsic and extrinsic motives* (Juho Hamari et al., 2014; Lister et al., 2014) *especially in mundane activities like PA*. This idea follows from gamification, which is the application of strategies from game design (e.g., actions, challenges, and achievements) to non-game activities to help make people's actions more engaging (Deterding, Dixon, et al., 2011). Persuasive technologies like gamification have been instrumental in effecting behaviour change in users in diverse fields ranging from education, marketing, crowdsourcing, management information systems to health and wellness domains, to mention a few. This thesis investigates the applicability of such affordances for PA motivation of older adults using technology.

Understanding consumers (older adults) and their intrinsic and extrinsic motivation for PA is an essential primary strategy for the design and development of technology solutions facilitating PA. To address this, I designed the Kaleidoscope of Effective Gamification (KEG) as a design and analytical lens to assist designers in developing gamification strategies for applications in any domain.

To better understand the personal motivations for older adults to engage in physical exercise, I collaborated with the Centre for Elder Research (CER), Oakville, to explore the factors that motivated older adults to engage in technology-facilitated PA. To do this, I analysed rich qualitative data provided by CER. I conducted a thematic analysis of qualitative data from a semi-structured interview study (Section 5.3.1.1) undertaken at the CER with 19 participants.

I followed this with a focus group study (Section 5.3.1.2) with three pairs of participants, consisting of personal trainers and older adults. Thematic analysis of this preliminary study identified design strategies for gamified PA applications for older adults, and guidelines for improving the engagement of older adults in PA. The results of these studies were published recently (Kappen et al., 2016) and provided the groundwork for the development of an Exercise Motivation Technology Framework (EMTF) for older adults' (Section 5.6). These preliminary

studies (Phase 1) helped identify PA needs and challenges faced by older adults. I outlined the challenges of measuring the player experience of older adults in the context of PA and gaming, which are explained in the research paper positing design strategies for this demographic (Kappen et al., 2016).

While younger adults indicated increased exercise adherence as a result of motivational affordances, there was limited research available on the preference of these affordances for PA motivation among adults in different age groups. To address this limitation, I conducted a survey study (Phase 2) on the preferences of motivational affordances for PA across different age groups which led to age-group specific design guidelines which were based on motivation to participate in PA, facilitating goals for PA, and continuance of PA.

To test these guidelines and the EMTF, I collaborated with researchers and fitness trainers responsible for training older adults, to develop Spirit50, a gamified technology artifact (Phase 3). Spirit50 was specifically designed for adults over 50 years of age and incorporated a few gamification elements: goal definition (quest), daily challenges, goal progression meter, points and badges (stars) as motivational affordances (gamification). User testing, evaluation and modifications of the Spirit50 artifact was conducted in an iterative manner following the Design Science Research Methodology (Vaishnavi & Kuechler, 2013)(Section 4.1). These motivational affordances focussed on enjoyment, competence, and personalised virtual coaching designed to increase the engagement of adults over 50.

Furthermore, to understand PA motivation on a granular level among adults (50+), I conducted an experimental study (Phase 4) which was a synchronous, three-condition (gamified, non-gamified, control), eight-week study with a total of 30 participants. In this study, to examine the influence of motivational affordances through technology artifacts, physically active adults were randomized into one of three conditions: gamified PA, non-gamified PA, and control group.

Additionally, I conducted an expert evaluation of the Spirit50 artifact to review the technology facilitation of PA (Figure 43), its applicability and usefulness from an older adults PA gamification perspective (Phase 5). With the identification of motivational characteristics among

older adults, I developed guidelines for designing an adaptive (Smeddinck et al., 2013) (Section 10.5) fitness application using gamification. This application addresses the needs, barriers, motivations, and amotivational attributes of PA engagement through fitness gamification.

My work on social interaction in public spaces and learning has resulted in a full paper publication at CHI PLAY 2014 (Kappen et al., 2014), design strategies for older adults at the Hawaii International Conference on System Sciences-49 (HICSS) (Kappen et al., 2016), and works-in-progress publications at CHI 2013 (Kappen, Gregory, et al., 2013)(Wehbe et al., 2013) and Gamification 2013 (Kappen & Nacke, 2013)(Kappen, Johannsmeier, & Nacke, 2013). Additionally, materials from this paper are under review for a journal publication and two HCI conferences.

1.4 Thesis Contribution

This thesis contributes to the advancement of human-computer interaction by the following: a) the development of *Adaptive Engagement Guidelines* for PA technology for older adults, b) *Exercise Motivation Technology Framework (EMFT)* - a tool to aid in the design and development of PA technology, and c) *Kaleidoscope of Effective Gamification (KEG)* - a design and analysis tool to help designers design and develop gamified apps.

This thesis identified that enjoyment and engagement in PA is influenced by motivational affordances and the ability to participate in PA. In this thesis, I investigated the potential of customizing and personalizing goals, challenges, and achievements within the health and well-being domain using gamification elements, and how to adapt them for the limitations and challenges faced by older adults in relation to their PA. I refer to this as *adaptive engagement* when using persuasive technology solutions for PA motivation and engagement.

I developed the KEG, a design and analytical tool to help designers and developers build gamification technology based on the analysis of current gamification frameworks. The KEG integrates the Self-Determination Theory (SDT) (R. M. Ryan & Deci, 2000a), an evolving theory

of human motivation and game elements in an iterative and layered approach, to help serve as a step-by-step guideline for developers of gamification apps.

While prior research indicated the relevance of intrinsic motivations in traditional PA (Brox & Hernandez, 2011; M. Dacey et al., 2008), preliminary studies (Section 5.3.1.1 and Section 5.3.1.2) investigating the motivations of older adults towards technology-facilitated PA, indicated the impact of intrinsic motivations for successful gamified PA (Kappen et al., 2016). In Phase 1, investigating the needs and wants of a sample of older adults (active and inactive) with different perspectives on fitness motivation led to the development of the EMTF (preliminary framework) for this demographic. This phase helped to differentiate the needs and wants of older adults in the context of PA into vague-goals (long-term goals), specific goals (short-term goals), barriers to PA and current health conditions.

The survey study (Phase 2) helped with the creation of age-differentiated motivational affordances for four age groups: 18-29 (G1 - younger adults), 30-49 (G2 - middle aged), 50-64 (G3 - older adults), and 65+ (G4 - seniors). This study helped with differentiating motivational elements into gamified motivational affordances and quantified tracking metrics called feedback elements.

I applied the KEG design model and the preliminary EMTF to develop Spirit50 (Phase 3), a gamified PA technology specific to the 50+ older adult demographic. This gamified application enabled the customization and personalization of exercise routines taking into consideration their goals, barriers to PA, current health conditions thus contributing to balancing their exercise routines and their physical abilities.

Thematic analysis of the semi-structured interview data from the eight-week study (Phase 4) helped to identify motivational affordances specific for older adults' PA technology. From a technology artifact perspective, these motivational affordances were categorized based on intrinsic motivation, extrinsic motivation and feedback elements. Furthermore, quantitative analysis of the data indicated that technology facilitation of PA can be achieved through the usage of motivational affordances through the gamification construct.

Expert evaluation (Phase 5) of the guidelines for technology facilitation also pointed to the usefulness and the applicability of the technology artifact as a medium for delivering PA solutions to older adults. These studies led to the revised EMTF.

This thesis showed that fostering intrinsic and extrinsic motivation among older adults for PA can be done through the usage of motivational affordances. The EMTF serves as a valuable tool for designing PA for older adults facilitated by technology. Finally, this thesis contributes to tailoring and personalizing of adaptive engagement strategies using gamification as one potential way to deliver age-centric PA solutions for older adults.

1.5 Research Trajectory

This dissertation investigated the customization and personalization of motivational affordances to foster engagement of older adults through the design of gamified PA interventions. It discusses the breadth of PA research and examines the challenges and opportunities in engaging older adults in digital games in PA.

In the context of this thesis, I define *fitness gamification* as: *the use of game design principles to influence motivated participation in PA exercise routines using behaviour change theories.*

Figure 1 depicts the steps taken during my PhD research to investigate the engagement and experiences of older adults in the context of gamified PA applications.

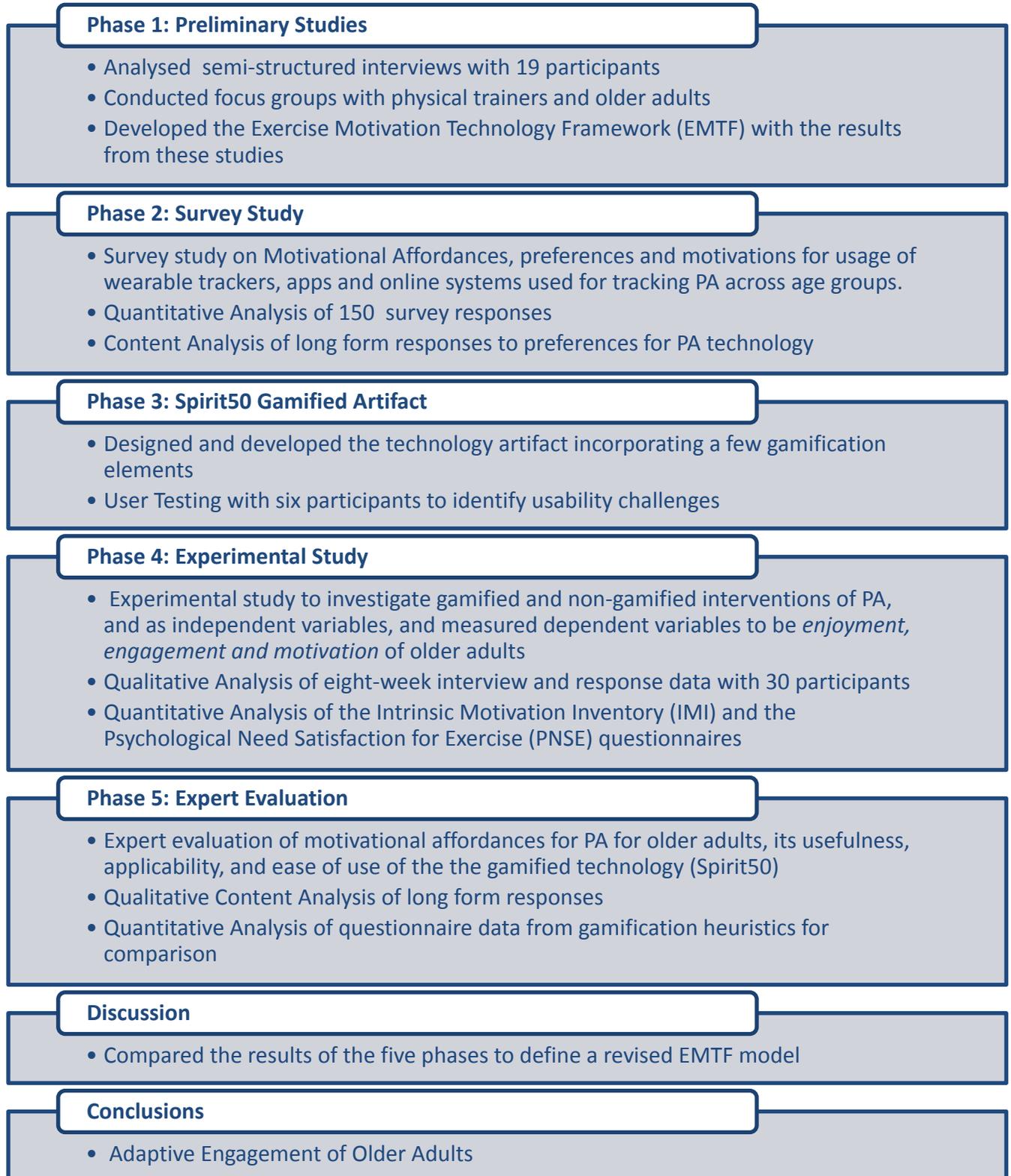


Figure 1: Research Trajectory Mapping.

I reviewed literature with the goal of demonstrating that certain motivational factors have more relevance to older adults and how they adopt technology (Bird et al., 2015). This is crucial, as many aging people face struggles to stay healthy (Ronald M Baecker, Moffatt, & Massimi, 2012), and gamification allows us to design interactive systems to combat these challenges (Kappen et al., 2016; Zuckerman & Gal-Oz, 2014).

My mixed-method investigation using qualitative interviews and focus groups (Section 4.6.1), survey study (Section 4.6.2), an experimental study (Section 4.6.4), expert evaluation study (Section 4.6.5) were designed to evaluate the EMTF (Section 5.6). These studies investigated what motivates older adults for PA and how we can make these technologies engaging.

1.6 Dissertation Organization

Chapter 2: Literature Review - This chapter provides background information relating to the following: older adults and usability; social interaction, motivations to play games, older adults personalities, motivations and fitness, gamification and fitness, and older adults and physical activity. This chapter provides information on traditional PA interventions and gamified technologies to encourage PA among older adults.

Chapter 3: Theoretical Framework - Based on the literature review, this chapter discusses the theoretical framework from the usage of behaviour theories to influence behaviour change towards participation in physical activities. Furthermore, the chapter discusses the KEG (Kappen & Nacke, 2013) as a design lens to be used to create behaviour change PA technology.

Chapter 4: Research Methodology – This chapter explains the Design Science Research Methodology, problem definition, research goals and methods, hypothesis and research questions. Furthermore, the chapter reports on qualitative studies from related research. To ground this dissertation, this chapter outlines the phases of this dissertation summarizing the studies conducted that lead to the development of adaptive engagement guidelines for older adults.

Chapter 5: Phase 1 – Preliminary Studies: Building on the methodology, this chapter discusses the analytical framework used to analyze rich qualitative data from initial studies (Sections 5.3.1.1 and 5.3.1.2) and the results of these preliminary studies.

Chapter 6: Phase 2 - Survey Study on Motivational Affordances: I designed a survey study to investigate motivational affordances of adults over 18 years of age. I grouped the data into four age categories based on prior research. This chapter illustrates the method, procedure, results from the survey. I present age-differentiated design guidelines for implementing motivational affordances in PA technology.

Chapter 7: Phase 3 – Spirit50: This phase involved the design and development of a gamification application for older adults (Spirit50.com).

Chapter 8: Phase 4 – Eight-week Experimental Study: This chapter demonstrates an experimental study using a gamified application as an intervention for adults over 50 years of age. I randomized 30 participants into three groups (gamified, non-gamified, and control) to evaluate the motivation, enjoyment and engagement among older adults using technology for PA.

Chapter 9: Phase 5 – Expert Evaluation: This chapter illustrates the expert evaluation of a gamification application (Spirit50) using heuristics and questionnaire to review the technology facilitation of PA, its applicability, usefulness and ease of use of the Spirit50 application in the context of the guidelines of motivational affordances for PA by older adults.

Chapter 10: This chapter summarises findings from the five phases of this PhD dissertation and provides a discussion on the role of gamification as a strategy for designing PA technology for older adults. The guidelines for adaptive engagement of older adults using gamification as a behaviour change mechanism is presented here.

Chapter 11: The concluding chapter highlights the key contributions of this thesis and discusses benefits, limitations and future work.

Chapter 2

2 Literature Review

This chapter presents an overview of older adults in the context of their motivation to play digital games, comparing younger adults and older adults' motivation towards PA, reviewing gamification, fitness and motivational affordances, comparing traditional and gamified technologies, usability and social interaction. Whitcomb's research discussed the benefits of digital games ranging from improvements in perceptual-motor speed to social and educational enrichment (Whitcomb, 1983). Nap et al. indicated that for seniors, game preferences and the motivations to play were real-life graphics, relatable scenarios, and training their brain and reflexes (Nap, Kort, & IJsselsteijn, 2009). Skill development in playing digital games demanded eye-hand coordination, dexterity, fine/gross motor skills, cognitive abilities (information processing, testing, reading, comprehending, decision making and memory) and attention span (Whitcomb, 1983). This necessitated the need for designers to implement usability criteria (interface design, meaningful metaphors related to real-world actions, adapting broad range of situations like public and private spaces) (Gerling, Schulte, & Masuch, 2011) and improved accessibility of digital games for better user experience by older adults (Brox, Konstantinidis, & Evertsen, 2017). How older adults interact with gaming technology is influenced by their physical limitations (Anton et al., 2015; Sjors, Bonn, Trolle Lagerros, Sjolander, & Balter, 2014; Sun, Norman, & While, 2013). Their interest to play digital games also stems from their ability to use technology (Marston, 2013; Wang & Rau, 2011). I reviewed literature on the motivation to play digital games, the comparison of gamification for different age groups, gamification, fitness and the perspectives of older adults on digital games, and compared traditional and gamified interventions in the context of PA.

2.1 Motivation to Play Digital Games

While some studies have researched interface design of games for older adults (Apted & Quigley, 2006), the positive impact of games on an older person's mental and physical well-being (IJsselsteijn et al., 2007), the effects of age on structural elements of games (Gerling,

Schulte, et al., 2012), and the motivation and engagement of senior gamers has not been extensively researched. Thorough investigations of demographic behaviours and attitudes related to digital gaming will reveal new opportunities for improving the accessibility of applications designed for older adults. Though some usability challenges like game speed, interface font sizes, dexterity of movement and maneuverability, have been identified, some seniors play games to escape from reality, for fun and relaxation, or for educational reasons (Nap et al., 2009). Older adults find applications and devices that appear highly technical to be intimidating and challenging (Picking, Robinet, Grout, McGinn, & Roy, 2009) because of the higher cognitive load (Ijsselsteijn et al., 2007). This, in turn, presents an impediment to their motivation to play or engage with such technology. Several aspects of integrating accessible technologies, such as intergenerational interactions, social and familial interactions were examined through the inclusion of older people in exploring the accessibility of computer-based technologies for this population (Harley, Vetere, Fitzpatrick, & Kurniawan, 2011). Challenges resulting from a fear of the complexity involved in installing and playing games were amotivational factors for older adults with respect to gaming (Mahmud, Mubin, Shahid, & Martens, 2008).

2.1.1 Understanding Older Adults' Perspectives on Games

Research has evaluated the preferences and needs of older adults in the context of video game play. Among the first to explore this areas are De Schutter and Vanden Abeele (Vanden Abeele & Schutter, 2010), who suggested that connecting with others, self-cultivation, and being able to contribute to society are factors that older adults consider important in the context of games. Brown examined older adults' motives to play and found that enjoyment, social aspects, and perceived health benefits were major motivators for older adults to engage in games (Brown, 2012). Nonetheless, results on the social context of play are contradictory, and some research suggests that older adults might prefer solo play over multi-player settings, which should be addressed in gamification (Rice et al., 2013; Romero, Sturm, Bekker, de Valk, & Kruitwagen, 4392).

While the above research focused on the standalone activity of gaming and not the integration of PA, my work contributed by combining these two fields. I chose to carry out this work focused primarily on the facilitation of PA, rather than games, to provide older adults with a more relatable primary need of overcoming sedentariness. Existing research in this field of gaming

technology explores age-related needs of older adults related to gaming (Gerling, Livingston, et al., 2012a), barriers and motivations towards physical activities and sustaining healthy activity levels (Schutzer & Graves, 2004a), and a client-centered counselling approach [38] to motivate older adults towards fitness activities.

2.1.2 Motivation and Fitness Games

Older adults are reluctant to pursue active fitness programs because of the challenges of aging (Czaja, S. J, Lee, 2007). *Curious Companion* integrated a Chinese Water Painting Game encouraging movements and variable speed of motion to complete a digital Chinese poem (Wu, Miao, Tao, & Helander, 2012). Robot Games for the elderly (Hansen, 2011) implemented taking a ball from a robot and handing it back while the robot moved. *SilverPromenade*, a movement based game, took the player on a virtual walk in nature (Gerling, Schulte, et al., 2012). All of these games explored tools for promoting physical activity among older adults. Studies on full-body motion control games showed that games can have positive effects on the emotional wellbeing of older adults, leading to guidelines for the design of full-body interaction in games (Gerling, Livingston, et al., 2012a).

Many researchers have explored the SDT (R. M. Ryan & Deci, 2000a) construct, which propounds the value of intrinsic and extrinsic motivations. While facilitating internalization occurs through the self-regulation processes of introjections and integrations (Deci, Eghrari, Patrick, & Leone, 1994a), social contexts and SDT supported integration. The Self-Motivation Inventory (Dishman & Ickes, 1981) aimed to identify variations in adherence to physical activity and dropouts (Goldberg, 1983) within female and male participants. The Exercise Motivations Inventory (EMI) (Markland, 1999) and Exercise Motivations Inventory-2 (EMI-2) (Markland & Ingledew, 1997) posited a collection of exercise participation motives in adults applicable to both exercisers and non-exercisers. This was used in a survey study (Phase 2) to investigate exercise motives in adults in different age groups.

The Psychological Need Satisfaction in Exercise scale (PNSE) (Wilson et al., 2006) validated high levels of need satisfaction in exercise contexts. This instrument has been used by researchers to investigate perceived competence, autonomy and relatedness while exercising (Direito, Jiang, Whittaker, & Maddison, 2015; Teixeira, Carraça, Markland, Silva, & Ryan,

2012) from an intrinsic motivation construct. Intrinsic motivation and self-determined extrinsic motivation defined the motivations of older adults towards physical activity (M. Dacey et al., 2008). The Intrinsic Motivations Inventory (IMI) (McAuley et al., 1989) discussed the need for accurate assessment of psychological constructs in a competitive sports setting. It showed, that some apparent intrinsic motivation may be extrinsically fuelled by rewards such as weight loss, improvements in physical appearance, and social recognition (Markland & Hardy, 1997). Since this dissertation focussed on investigating the intrinsic and extrinsic motivation of older adults in the context of PA, both these instruments were used in the experimental study (Phase 4) to investigate motivation, enjoyment and engagement of older adults.

The Canadian Physical Activity Guidelines recommend at least 150 minutes per week of physical activity for adults which could help reduce the risk of the following: premature death, heart disease, stroke, high blood pressure, diabetes-Type 2, and obesity (CFLRI, 2007; CSEP, 1999, 2012). Regular physical activity can lead to improvement in strength, fitness and mental health from a morale and self-esteem perspective. From an older adults perspective, these guidelines recommend 150 minutes of moderate to vigorous-intensity aerobic physical activity per week in units of 10 minutes (CSEP, 1999; World Health Organization, 2010). Therefore, it is important to investigate if persuasive technologies like gamification could be used to stimulate a minimum of 10 minutes of PA in blocks of 10 minutes.

2.2 Comparison of Motivation to Participate in PA

A systematic review of PA and exercise motivation grounded in SDT emphasized the importance of autonomous (identified and intrinsic) regulations over extrinsic regulations in fostering PA (Teixeira et al., 2012). Studies showed that there was a direct effect of self-determined regulation on habit strength (Gardner et al., 2014; Gardner & Lally, 2013). Participation in exercises was dependent on habit formation which needed a minimum of at-least four bouts of exercise over a six week period (Kaushal & Rhodes, 2015). Technology apps like Lift¹ (now *coach.me*) helped assist with habit formation for tracking diet, exercise, spirituality, personal hygiene, education and personal growth, but required continual usage (Renfree, Harrison, Marshall, Stawarz, & Cox,

¹ <https://www.coach.me/>

2016). However, this study did not address PA and motivational affordances. Additionally, while intrinsic rewards helped with promoting exercises in the initiation phase, habit formation helped with maintenance of the exercises over time (Gardner & Lally, 2013; L. A. Phillips et al., 2016). Furthermore, while motives to participate in PA are different across type of activity, age, and gender in adults (Molanorouzi, Khoo, & Morris, 2015), this study did not identify any motivational affordances in the realm of technology assisted PA. To explain the need to compare motivation to participate in PA in different age groups, we discuss younger adults and older adults in the context of PA and the usage of motivational affordances in gamified technology in the following sections.

2.2.1 Younger Adults and PA Facilitation

Self-determined situational motivation (i.e., the reason in one situation for someone to do something) drives self-determined contextual motivation (i.e., knowing what effect one has in doing something), and social factors such as recognition and comparing with others (J Hamari & Koivisto, 2013; Vallerand & Lalande, 2011), positively predicted younger adults participants' motivation towards exercise and PA (Lavigne et al., 2009). Studies involving younger populations participating in Tae Kwan Do and Aerobics revealed that adherence to exercise improved when there was a greater emphasis on enjoyment, competence, and social interaction, as opposed to motives focused on fitness or appearance (R. M. Ryan, Frederick, Lepes, Rubio, & Sheldon, 1997). Motivational affordances provided by a wrist-worn activity monitor had a short term positive effect on PA and sedentary activity (SED) in young men (Jauho et al., 2015). Monitoring of physical activity metrics and tracking was indicated to be motivating due to increased awareness of one's own behaviour (Meyer, Fortmann, Wasmann, & Heuten, 2015). While college students reported enjoyment and challenge to be intrinsic motives, extrinsic motives were focused on appearance, weight, and stress management as motives for PA participation (Marcus, Hebert, & Bartholomew, 2005). Motivational affordances were made possible through persuasive technologies and gamification and fostered social collaboration and PA (X. Tong, Gromala, Shaw, & Neustaedter, 2016). Goal setting in the form of daily step count helped facilitate increased PA (Bravata et al., 2007). The game *Fish 'n' Steps* investigated overcoming a sedentary lifestyle by encouraging participants to initiate PA where their daily step count led to the growth and actions of an animated character of a fish in a fish tank (Lin et al., 2006). However, the preferences of motivational affordances by younger adults in the context of

technology facilitated PA have not been investigated. I address this through a survey study detailed in Chapter 6.

2.2.2 Older Adults and PA Facilitation

Despite being interested in fitness activity, research suggests that many older adults are reluctant to pursue active fitness programs because of the challenges of aging (Elsawy & Higgins, 2010), which include social isolation, cognitive deterioration, mental distress, and a decline in motor controls (Czaja, S. J, Lee, 2007). The challenges of aging (Ji et al., 2010) also presented barriers to technology-supported fitness activity. Being unable to participate in PA because of age-related impairments (Czaja, S. J, Lee, 2007) is problematic, as it can lead to limited engagement in physical and mental leisure activities in a social environment. This can result in the proliferation of loneliness, and the amplification of adverse effects on cognition and physical abilities (Czaja, S. J, Lee, 2007; Ji et al., 2010). This impedes the adoption of a routine fitness lifestyle. The development of individualized programs tailored to address unique barriers faced by older adults (Allender, Cowburn, & Foster, 2006; Brawley, Rejeski, & King, 2003) necessitates the need for customization and personalization of PA.

For older adults actively involved in PA, studies show that intrinsic motivation is greater than extrinsic motivation (Buckworth, Lee, Regan, Schneider, & DiClemente, 2007). In contrast to the motivating factors for PA seen among younger participants, studies show that for older adults, intrinsic factors are a greater motivator than extrinsic factors (Gerling, Schulte, et al., 2012). Additionally, intrinsic enjoyment from exercising and socialising in a group was more prominent than extrinsic health benefits (M. L. Dacey & Newcomer, 2005; Edmunds, Ntoumanis, & Duda, 2006) thus linking fitness routines to motivating older adults to initiate and maintain fitness activities (E. M. Phillips, Schneider, & Mercer, 2004).

Prior research investigated the role of gamer types personality factors and technical expertise indicated that performance was affected by gamer type (Brauner et al., 2013). Furthermore, exergaming, a technology that combines exercise and gaming, helped improve perception among older adults on the usefulness of technology and its advantages to improve physical activity (Bird et al., 2015). This research focused predominantly on the relevance of gaming and its applicability in rehabilitation, physical and cognitive training, leisure and entertainment, and

adult learning. Wii games had a positive impact on the overall well-being of the elderly, where moderate-intensity PA were preferred over more difficult or strenuous routines (Jung, Li, Janissa, Gladys, & Lee, 2009a; Schutzer & Graves, 2004b). Motivational characteristics, such as purposeful interactions, customization of activities, fostering independence, building relationships, sharing and accommodating preferences (Kappen et al., 2016) are common among older adults, which relate to their lifestyle attitudes. Additionally, improved wellness and decreased sedentary time (Barwais et al., 2013), prescriptive interventions using casual video games were implied to prevent and treat stress (Russoniello, O'Brien, & Parks, 2009), as well as improve the mood of participants.

2.3 Gamification, Fitness and Motivational Affordances

While gamification relies on intrinsic and extrinsic motivations provided by a gamified application, Larsen studied that within the context of PA, users' external motivation could increase their internal motivation over time (Larsson, 2013a). Influencing human behaviour using game design principles in decision-making applications and services (Kappen & Nacke, 2013) posits behaviour change elements to foster intrinsic motivation. Customization of these gamification elements based on demographics or age groups can contribute to personalization of playful technologies.

In the context of playful and persuasive technologies, McGonigal coined the term *gamefulness* and she explained that gamefulness is the good feeling that is achieved when playing an engaging game (McGonigal, 2011; Takahashi, 2011). Deterding et al. defined gamefulness as an experiential and behavioural quality achieved through gameful design, which represented the usage of game elements to achieve gamefulness (Deterding, Dixon, et al., 2011). Lucero et al. used the terms gamefulness and gamification interchangeably in their PLEX framework to describe a lusory attitude in an activity (Lucero, Karapanos, Arrasvuori, & Korhonen, 2014; Bernard Suits, 1978). The lens of *skill atoms*, which are essential building blocks of games and establishes a feedback loop between the user and the system (Deterding, 2013) relates gameful design and user activities to the design of motivating and enjoyable experiences. Differentiating these skill atoms to different age groups based on preferences, needs and wants is critical for the

design of technology artifacts. Gamification addresses motivational mechanisms and fosters a desire to engage with the system (Sailer, Hense, Mandl, & Klevers, 2013). Additionally, social motivations predict attitudes towards the use of gamification, and intentions to continue using a gamified service (Juho Hamari & Koivisto, 2013). Such social factors can be compared between age groups to enable personalization of technology devices. This led to comparison of motivational affordances including social factors across age groups through a survey study in Phase 2.

Exploration of physical activities through gamification (Gerling, 2011) could help provide access to these activities otherwise inhibited by age-related challenges. Therefore, investigation of motivational affordances based on demographic characteristics such as age groups can better our understanding of implementing gameful design elements in technological artifacts. These challenges can be categorized as social isolation, cognitive deterioration, the decline in motor controls, physical restrictions, emotional loneliness, and mental distress (Belchior et al., 2012; Czaja, S. J, Lee, 2007; Elsayy & Higgins, 2010). Some of these challenges can be individually addressed using technology (Ronald M Baecker et al., 2012) and digital game design (Belchior et al., 2013; Gamberini et al., 1999). Guidelines for the design of full-body interaction in games provide basic barriers to consider when designing such interaction activities for older adults (Gerling, Livingston, et al., 2012a). Senior citizens (65+) were also keen to play simple games having uncomplicated rules (Mubin et al., 2008).

Lister et al. indicated the potential of gamification to change health behaviours through the usage of game elements in fitness and health apps (Lister et al., 2014). King et al. reported strategies to influence health behaviours leading to the collective aim to develop digital ‘games with a purpose’ (D. King, Greaves, Exeter, & Darzi, 2013). Additionally, maintaining adherence in mundane and boring activities such as exercises and daily physical activities are fostered by motivational affordances (Juho Hamari & Koivisto, 2015b). Motivational affordances’ expressing quantified achievements in the form of numeric and progressive feedback have contributed to increased participation in PA (Zuckerman & Gal-Oz, 2014). For instance, Apple has just released a new mobile operating system with a health tracking app (compatible with a smart watch capable of everyday physiological data tracking), and other wearable solutions like

Fitbit (“FitBit,” 2015) and Nike+ FuelBand (“Nike+ FuelBand,” 2014). Online health tracking websites have emerged with solutions like Fitocracy (“Fitocracy,” 2015) and FitOrbit (“FitOrbit,” 2015). However, little research has been done to compare the motivation to use these technologies for adults in different age groups.

While research on the general intrinsic and extrinsic motivation of older adults (M. Dacey et al., 2008) affirmed interest levels towards engaging in PA, more research on player personality characteristics from gamer personality is needed to understand attitudes and motivation of players (users) (Bartle, 1990). Existing research explores age-related needs of older adults (Gerling, Livingston, et al., 2012a), barriers and motivations towards PA, and activity levels (Schutzer & Graves, 2004a)(M. Dacey et al., 2008). Further research is necessary to define the personality traits and motivational characteristics of older adults compared to player typology (Bateman, Lowenhaupt, & Nacke, 2011).

A study of exercise habits in younger participants (mean age = 21) revealed that adherence (continued participation in PA or exercise routines) was associated with motives focused on enjoyment, competence, and social interaction in contrast to personal fitness or appearance (R. M. Ryan et al., 1997). Health benefits resulting from the observation of fitness routines (Nied & Franklin, 2002) are linked to motivating older adults (mean age = 78) to initiate and maintain fitness activities (E. M. Phillips et al., 2004). Research on the intrinsic and extrinsic motivations older adults (mean age = 63.8) (M. Dacey et al., 2008) explored their activity levels (in-actives, actives, sustained maintainers) against dimensions of health and fitness, weight management, appearance, stress management, enjoyment, emotion, and sociality. For younger adults (mean age = 18.6) actively involved in PA, studies showed the relative importance of intrinsic motivation over extrinsic motivation for exercise maintenance (Buckworth et al., 2007; Rice et al., 2013). In this context, a comparison between age groups was not done and samples were specifically focused either towards the young population or the older population. While motives for participation in PA differ for the young and older population, a comparison of these exercise and PA participation motives between adults in specific age groups is in need of research investigation.

While research has shown that gamification affords the interjection of motivational affordances into mundane activities as exercise routines and physical activity (Lister et al., 2014), it is critical to investigate the relevance of these affordances for different age groups. Additionally, physical activity is important at all life stages, and while health technologies and gamified fitness strategies have been widely adopted by the younger population, little research has been done on comparing the motivational affordances facilitated by technology between different groups wishing to maintain physical activity routines. When participating in PA, researchers examined the intrinsic and extrinsic motivations of older adults to engage in physical activity (M. Dacey et al., 2008; Marston, 2013), and younger adults motivation for PA (Murray, 2006; Rice et al., 2013). To the best of my knowledge, there has been no research conducted on the comparison of motivational affordances preferred by adults in different age groups in using gamified fitness applications as influencers of PA participation. In Chapter 6, I describe the study design and analysis of a survey study that queries the similarities or differences in motives to participate in PA and the influence of motivational affordances as a technology facilitator for PA.

2.4 Gamification and Behaviour Change

Persuasive technologies using gamification as a strategy have been used to foster motivation indicated emergent themes such as feedback and monitoring, reward and threat, and goals and planning (Edwards et al., 2016). Gamified app-based interventions to improve diet, physical activity and exercise indicated significant health improvements in comparison to stand-alone apps (Schoeppe et al., 2016). Tailoring these apps based on the personality traits of users could increase their efficacy (Orji, Nacke, & DiMarco, 2017). While incorporating challenges and accountability facilitated usage of persuasive strategies within a gamified design, challenges with privacy (sharing personal information) and reduced self-confidence hindered effective deployment of these gamified apps (Orji, 2017). A systematic review of empirical studies on gamification in the health and wellbeing domains indicated a positive impact towards health behaviours (Johnson et al., 2016). While this study indicated that targeted health and well-being domains were: physical health (exercise and fitness), healthcare utilization (dispensing, medication usage and monitoring glucose levels, patient empowerment), and mental health (stress and anxiety reduction, it also indicated that several studies reviewed reported mixed or

neutral effects of gamification. Gamified web interventions for rheumatoid arthritis patients indicated increased empowerment, app usage and PA than the control group (Allam, Kostova, Nakamoto, & Schulz, 2015). Systematic reviews on gamification literature have called for comparing gamified interventions with non-gamified interventions (Johnson et al., 2016; Seaborn & Fels, 2014). This inspired the comparison of the differences between gamified and non-gamified PA interventions in this dissertation (Section 2.5 and 2.6).

Many commercial systems have combined gamification with PA (Lister et al., 2014) as a behaviour change strategy to help individuals achieve health and fitness goals. As part of this, fitness trackers motivate workout activities by providing feedback (Pereira et al., 2014). Gamification or gameful design as a form of persuasive technology offers many hedonic (pleasure, enjoyment, comfort, absence of distress) and eudaimonic (growth, meaning, authenticity, excellence) (Huta & Waterman, 2014; Tondello, Wehbe, et al., 2016) pathways to implement persuasive strategies to motivate older adults to initiate, maintain, and adhere to healthy behaviour.

2.5 Traditional or Classic Physical Activity Interventions and Measures

In Section 2.5 and 2.6, I present an overview of traditional PA interventions and gamified PA interventions to set the research background for an experimental study in Phase 4. While faced with the challenges of aging, lifestyle interventions in the form regular PA interventions can help mitigate certain chronic conditions due to sedentary lifestyle (A. C. King, Rejeski, & Buchner, 1998). Traditional PA activities targeted strengthening of muscles, the flexibility of body and balance in the form of strength training, cardio respiratory fitness, aerobic exercises, aerobic dance, aerobic aquatics, jogging, walking and step training (A. C. King et al., 1998), to mention a few, formed a critical collection of activities, which contributed towards health-related QoL². Many PA interventions used behavioural or cognitive-behavioural strategies such as goal setting, self-monitoring, feedback, support, stimulus control and relapse–prevention training (A. C. King, 2001). Ongoing telephone instruction and supervision combined with home-based PA programs

² Quality of life

were more effective than face-to-face instructional activity or class-based group activities (A. C. King, 2001). Print and telephone-mediated PA interventions indicated an increased activity over print only mediated interventions (Ball, Salmon, Leslie, O, & King, 2002). PA adherence was greater with telephone counseling and mail interventions (Castro, King, & Brassington, 2001). Interventions designed on the basis of behavioural theory constructs provided robust (Weber & Sharma, 2011) conclusions on the efficacy of the PA interventions. Contrasting health outcomes and behavioural outcomes due to PA interventions revealed that interventions which emphasized behavioural strategies over cognitive strategies (Conn, Hafdahl, & Mehr, 2011) provided greater effectiveness in health outcomes.

Measures

The effectiveness of traditional PA interventions for seniors was examined using the physical activity questionnaires to measure changes in PA over time using the Physical Activity Scale for the Elderly (PASE) (Bolszak et al., 2014) and the Community Healthy Activities Model Program for Seniors (CHAMPS) (Stewart et al., 2007). The 41 item CHAMPS, a self-report measure of physical activity with demonstrated validity and psychometric properties (Wilcox et al., 2009), includes multiple activities undertaken by older adults. Short Questionnaire to Assess Health-Enhancing Physical Activity (SQUASH) was used as outcome measures in the study of an environmentally tailored PA intervention (van Stralen et al., 2009).

Use of accelerometers to assess PA objectively, in combination with self-reported health by older adults' indicated good participant compliance with the study protocol (Lohne-Seiler, Hansen, Kolle, & Anderssen, 2014). A moderate to vigorous physical activity (MVPA) study indicated the need for activity specific, flexible accelerometer cut points for older adults (Pruitt et al., 2008)(Evenson et al., 2012). The Table 1 outlines examples of the measures that were used in the above studies and provides a guide for the selection of a non-gamified intervention and relevant measures for the experimental study (Phase 4).

PA Intervention	Measures	Instrument	Feedback	Reference
Brisk Walking	speed	Accelerometers	Self reporting	(Lohne-Seiler et al., 2014)
400 m walk	Time and rate	ActiGraph accelerometer	Data	(Pruitt et al., 2008)(Evenson et al., 2012)

Cycling	speed, rate	SQUASH	Computer based	(van Stralen et al., 2009)
Active for Life (AFL)	adherence	PACS	Telephone based program	(Bolszak et al., 2014)
Group Exercises	adherence	CHAMPS	Self-Reporting	(Stewart et al., 2007)

Table 1: Traditional or Classic Physical Activity Interventions and Measures

While computer-tailored (CT) physical activity interventions can reach a wider audience, the effectiveness of CT-based PA was inconclusive (Neville, O'Hara, & Milat, 2009) for adults. A comparative study between a basic computer-tailored PA intervention without environmental information and with environmental information (cycling routes, sports clubs and information matching their interests), as well as access to a forum and e-buddy on a website, significantly improved cycling behaviour (van Stralen et al., 2009).

This indicates that PA among older adults increased when it is supported by the combination of technology-enabled intervention and traditional mediations in the form of weekly repeated telephone calls, print, and mail media. This helped sustain the effectiveness of PA interventions. Providing older adults with mediation through technology, in conjunction with PA intervention helps to reinforce the need to participate in PA and sustain PA over time. Technology supports behaviour change among participants towards PA with the use of motivational PA interventions. This indicates that non-gamified PA interventions are a viable method for influencing PA activities among older adults. In the context of this dissertation, this section provided background research regarding such studies to help with the selection of a non-gamified PA intervention for the experimental study in Phase 4.

2.6 Gamified Technologies to Encourage Older Adults' PA

Gamified technologies in the form of exergames (games involving physical exercise), web-based interventions and fitness applications involving gameplay, provide a diverse spectrum of available technologies to initiate and maintain PA among older adults. Seniors preferred games that simulated true-to-life scenarios, provided cognitive training and digital games that helped to improve their reflexes (Nap et al., 2009). Furthermore, in-person and electronically mediated interventions through persuasive games (Rovniak et al., 2013) and inter-personal

communications (Riche & Mackay, 2009) were shown to be effective for influencing and motivating health behaviour change (Orji, Mandryk, Vassileva, & Gerling, 2013). Additionally, home-based health monitoring practices (Grönvall & Verdezoto, 2013), as researched in Mediframe (Daalgard, Grönvall, & Verdezoto, 2013) and in-home rehabilitation technologies (Axelrod et al., 2009) discuss challenges in the implementation of these technologies due to age-related infirmities and diseases. Gamification applications like Superbetter³ focused on negotiating life's challenges such as depression, anxiety, pain, finding a job, improving a skill and strengthening a relationship to mention a few, into a gamelike experiential play supported by motivational affordances. Habitica⁴ and coach.me⁵ are also examples of gameful technology that provide the impetus to role playing life in the form of setting up goals, with in-game rewards, punishments and social facilitation.

Many older adults are growing accustomed to evolving technologies and omnipresent video games. New input technologies for these games are becoming more intuitive for an aging demographic of gamers (e.g., movement interfaces such as the Microsoft Kinect (Brox et al., 2017), the Nintendo Wii controllers (Jung et al., 2009b), large screens present on mobile tablet computers and smartphones).

Research has explored the design of motion-based games with the goal of facilitating occupational therapy and rehabilitation among older adults. Recent examples include motion-based games for stroke rehabilitation where the patient recovered significant motor abilities over a six-week period (Alankus, Lazar, May, & Kelleher, 2010), therapy for older adults with Parkinson's disease (Smeddinck et al., 2013), and balance training to reduce the risk of falls among older adults (Laufer, Dar, & Kodesh, 2014; Smith et al., 2009). Motivating older adults in PA with focused gameplay over long periods was seen as an advantage of exergaming (Brox, Åsheim-olsen, & Vognild, 2014).

³ www.superbetter.com

⁴ <https://habitica.com>

⁵ www.coach.me

Different approaches have been taken with regard to the promotion of exercise and PA. Non-commercial games like UbiFit Garden provided feedback in the form of flowers based on daily physical activities (Consolvo et al., 2006) and Flowie provided feedback on increased number of daily steps taken by the participants (Albaina, Visser, van der Mast, & Vastenburg, 2009), targeted the older adult population, and aimed to encourage PA through persuasive technology intervention (Fan, Forlizzi, & Dey, 2012). While this helps to promote PA, mobile apps can also promote activity using smartphones, focusing on individually tailored feedback and advice (Geurts et al., 2011). While playful persuasive solutions (Romero, Sturm, Bekker, de Valk, & Kruitwagen, 2010), embodied gaming (Aarhus, Grönvall, Larsen, & Wollsen, 2011) and augmented gaming (Mahmud, Mubin, Shahid, & Martens, 2010) can facilitate fun and socially engaging activities, key intrinsic and extrinsic reasons for sustaining motivation in these activities have not been identified.

Measures

Increase in motivation to participate in PA (Brox et al., 2014), enthusiasm for playing together within peer groups (Aarhus et al., 2011), influence of social-networks to support long-term PA (Rovniak et al., 2013) were a few of the benefits of gamified technology facilitated PA. Web-based intervention to promote PA indicated a positive impact on the activity levels among older adults (Irvine, Gelatt, Seeley, Macfarlane, & Gau, 2013). Additionally, in-home Wii Fit balance programs were as effective as outdoor body movement exercises such as Tai Chi (Pluchino, 2010) at improving adherence to exercise.

The benefits of gamified applications as referenced above, range from increased motivation (Brox et al., 2014), improved monitoring of daily activities, and tracking of goals attainment. Furthermore, gamified applications facilitated individuals to connect via community building and social networks (Rovniak et al., 2013).

While regular PA is important for older adults to maintain their long-term physical, cognitive, and emotional health (Bethancourt et al., 2014), little research has been done to understand the motivations of this group to initiate, engage in, and sustain regular PA. The majority of existing research work in this field is accessibility-driven and focused on the availability of tech-mediated PA. However, these approaches did not explore older adults' motives and barriers to exercise,

which are crucial factors in maintaining long-term user engagement. A theoretical understanding of these motivation and barriers is instrumental in developing fitness and or PA artifacts through gamification. To the best of my knowledge, such an understanding has not been previously explored and constitutes a valuable contribution to HCI. I address this issue of facilitating PA in older adults by investigating intrinsic and extrinsic motivations facilitated by technology, and providing insight into the challenges of designing gamified physical activity applications. I also conducted a systematic review of *Older Adults' Physical Activity and Exergames*⁶ which is currently under review for a journal publication. Based on my investigation of needs and wants of older adults and PA technology, I developed a gamified PA intervention (Spirit50) integrating barriers to PA and the current health conditions of older adults. The development of this gamified PA technology is presented in Chapter 7. This section provides research support for the use of gamified PA interventions for older adults thereby providing background information to inspire a randomized experimental study in Phase 4.

⁶ Under review for a Journal publication

PA Intervention	Gamified Tech	Measures	Instrument	Feedback	Reference
Balance and fitness	Nintendo Wii Fit	Balance	'Eight-foot up-and-go' test	Field notes and photographs	(Aarhus et al., 2011)
Walking, balance and movement	Nintendo Wii Fit	Balance	Coding and questionnaire	Notes	(Brox et al., 2014)
Walking	WalkLink+	Social networks, speed, endurance	Walking logs, convenient PA facilities questionnaire; Home exercise equipment questionnaire; Settings where PA was done (adapted scale)	Pre, During, Post, 6-month follow-up assessment	(Rovniak et al., 2013)
Balance program	Wii Fit	balance	Force plate postural sway (COP) and dynamic posturography (DP).	Follow-up assessment	(Pluchino, 2010)
Body gestures and movements	Non-commercial active games	Engagement	Pre-post PANAS	Follow-up assessment	(Gerling, Livingston, et al., 2012a)
Walking	Flowie: Non-commercial active games	Distance, speed	Wireless pedometer, persuasive technology acceptance model (PTAM) questionnaire	Assessment	[4]
Exercise routines	Active After 55 website	Engagement, adherence	SF-12, BMI, Ability to Exercise, Stage of Change	Pretest, 12 weeks, 6 months	(Irvine et al., 2013)

Table 2: Gamified Technologies to Encourage Older Adults' PA

2.6.1 Usability

In designing for an older demographic, many important considerations emerge related to user experience and interaction, and game interface design (L. E. Nacke, Costa, Kappen, Robb, & Buckstein, 2014). The ElderGames project focused on the development of games using advanced visualization and interaction interfaces to improve the cognitive, functional, and social skills of older users by providing them entertainment and training (Gamberini et al., 1999). Various

design criteria established for vision and hearing specified the importance of illumination, font sizes, ambient lighting and minimised dependence on peripheral vision (Schieber, 2003). These criteria related to perception, attention, learning, and memory, and everyday cognitive tasks that have defined design implications that affect interface design. A tabletop system, in which users shared photography projects (Apted & Quigley, 2006), led to a modified version of Nielsen's (Jakob Nielsen, 2002) usability guidelines and illustrated four guidelines for designers as a frame of reference for the design of games for older adults. These guidelines included larger interface elements, the importance of learnability and memorability, by reducing clutter and recognition of screens as important social spaces. These attributes are important when implementing gamified technologies for older adults.

2.6.2 Social Interaction

Social interaction is also another important context in helping older adults overcome their loneliness. Older adults suffer from age-related impairments leading to limited engagement in physical and mental leisure activities in a social environment (Czaja, S. J, Lee, 2007). This results in loneliness, which leads to further deterioration of their cognitive and physical activities (Ji et al., 2010). These issues impede their inclination to engage in fitness activities or maintain a consistently active lifestyle. Emotional isolation and cognitive deterioration can be accelerated by a lack of social interaction and communal activity (Grenade & Boldy, 2008). Persuasive strategies to encourage social interaction for older adults helped to improve social connections and provided subjects with companionship (Vargheese et al., 2016). The Active Parks project enabled sedentary park users to work together and bridge the generation gap (Tseklevs, Darby, Smith, & Gradinar, 2014). This raises the issue whether such social interaction could be provided on gamified platforms to help older adults overcome sedentariness and feel connected in a digital community environment.

2.7 Summary

Overcoming sedentariness is a major challenge for people from all walks of life and age groups. With the advent of mobile technologies such as smartphones, tablets and digital apps, the process of introducing motivational affordances to people to participate and engage in setting goals and objectives for themselves in a fitness activity becomes an easier task (Khot, Mueller, & Hjorth, 2013; Lister et al., 2014; Payne et al., 2015; Zuckerman & Gal-Oz, 2014). Usage of metaphors,

avatars, physical activity quests, goal progression and promoting daily physical activity can be seen in gamified apps like *Zombies Run!*⁷, *Superhero Workout*⁸, and *Nike +Running*⁹. Thus, gameful technology in the form of wearables and *mHealth* applications within the fitness domain encourages healthy behaviour ranging from monitoring daily physical activity, tracking health conditions, tracking fitness goals and achievements and establishing a sense of self control (Ferron & Massa, 2013; Kappen et al., 2016; Orji et al., 2017). However, most gamified technology has a one size fits all approach, which does not address specific needs, barriers to technology adaptation and selective goals of a specific demographic. More research is needed in the fitness domain for a granular categorization of motivations (intrinsic and extrinsic) across varying types of life challenges, goal setting, and reward mechanisms differentiated across age and gender. My dissertation fills this gap in the context of older adults PA by conducting a survey study, developing a gamified PA technology, conducting a randomized experimental study with a control group, and an expert evaluation to investigate PA motivation, enjoyment and engagement of older adults. I developed age-differentiated design guidelines for PA technology (Chapter 6) which provides categorization of motivational affordances for different age groups based on their PA preferences. Through an experimental study (Chapter 8) comparing three groups of participants (gamified, non-gamified, and control), I also identify specific motivational affordances that serve as triggers to foster intrinsic and extrinsic motivation of older adults.

⁷ <https://zombiesrungame.com/>

⁸ <http://superheroworkoutgame.com/>

⁹ <http://www.nike.com/>

Chapter 3

3 Theoretical Framework

Materials from this chapter have been published in a peer-reviewed conference proceeding and has been reproduced under License # 4164860077299 (Appendix 13.13).

Dennis L. Kappen and Lennart E. Nacke. 2013. The Kaleidoscope of Effective Gamification: Deconstructing Gamification in Business Applications. In *Proceedings of the First International Conference on Gameful Design, Research, and Applications - Gamification '13*, 119–122. <https://doi.org/10.1145/2583008.2583029>

This chapter discusses the theoretical constructs for behaviour change in the context of this dissertation because the combination of SDT and the KEG were used in all five phases of this investigation. Use of behaviour change theory or constructs in basing intervention strategies to encourage older adults in PA has often resulted in greater effectiveness (Antikainen, 2011; Carlson et al., 2012; Chase, 2013; Müller & Khoo, 2014; Stewart et al., 2007; Yeom & Fleury, 2014). The belief in one's ability to perform a physical activity also known as perceived behaviour change (PBC), a behavioural psychological mediator, resulted in increased physical activity participation (Antikainen, 2011) supporting the efficacy of theory-based motivational PA interventions (Weber & Sharma, 2011). To examine the appropriateness of a particular theory to support my research inquiry, I have provided a summary of relevant theories which facilitates behaviour change. I also provide my rationale for selecting a specific theory to influence my research inquiry.

3.1 Behaviour Change Theories

Key theories used for PA interventions are discussed in this section.

Theory of Planned Behaviour (TPB)

This theory (Figure 2) establishes that participants intentions (motivation) to engage in PA is greatly influenced by their attitude towards outcomes of a behaviour, subjective norm and their perceived behavioural control of the activity (Ajzen, 2015). The subjective norm represents the perceived social pressure to participate in an activity. Perceived behavioural control (PBC)

represents the extent of a participant's belief in their ability to perform an activity (Ajzen, 2015; Motalebi et al., 2014).

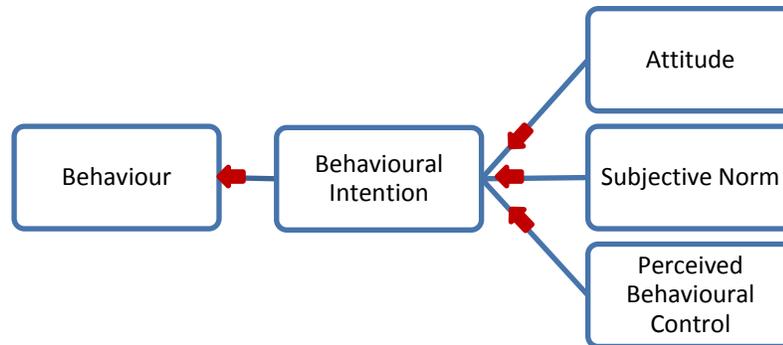


Figure 2: Theory of Planned Behaviour ((Ajzen, 2015))

This theory was used in a non-gamified web intervention for sedentary individuals to enable behavioural control facilitating a feeling of ownership thereby improving program engagement (Irvine et al., 2013). Priming of users intentions assisted with improving an individual's intention to participate in physical activity and increased duration of use of an exergame (Chen, King, & Hekler, 2014).

Social Cognitive Theory (SCT)

This learning theory (Figure 3) is based on the premise that people learn by observing others. Observed human behaviour is influenced by the dynamic interplay between personal factors (self-efficacy), behavioural factors, and environmental factors (Bandura, 2002). From the health behaviour domain, the SCT theory posits that human motivation, behaviour and well-being is influenced by one's self-efficacy beliefs (ability to complete a task, experience of mastery or being in control and verbal persuasion or feedback) which operate in conjunction with goals, outcome expectations, and environmental barriers and facilitators (Bandura, 2004).

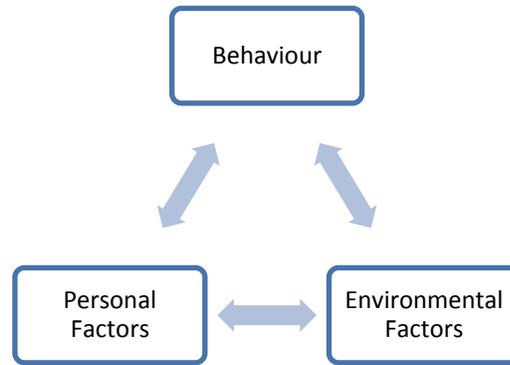


Figure 3: Social Cognitive Theory

Health - Belief Model (HBM)

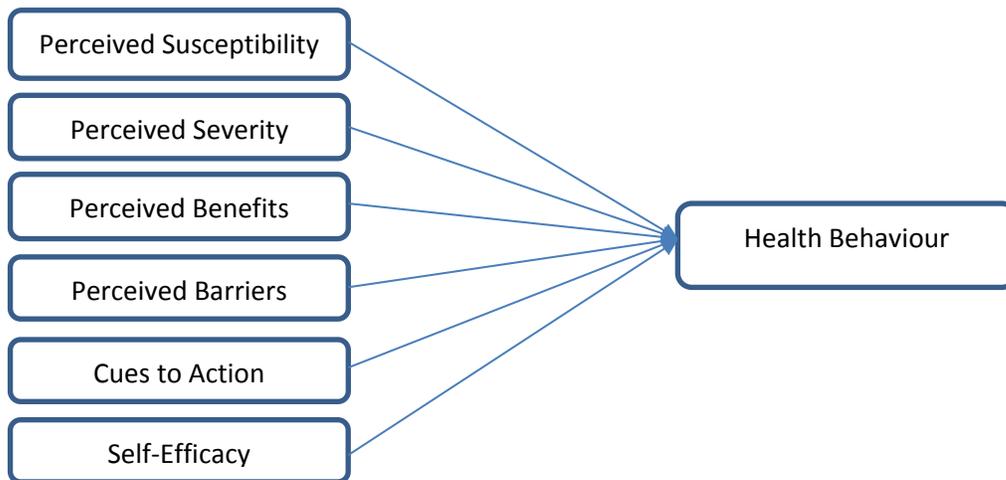


Figure 4: Health - Belief Model (Glanz, 2015; Janz & Becker, 1984)

This theory is a psychological behaviour change model (Figure 4), which posits that an individual's beliefs with regard to their health (perceived susceptibility, perceived severity, perceived benefits, perceived barriers and self-efficacy about their health problems) influence their readiness to take action (Glanz, 2015; Janz & Becker, 1984) to overcome their health challenges or illness.

Transtheoretical Model (TTM)

This theory (Figure 5), also known by the term “stages of change” (SOC) argues that an individual's readiness to change their health behaviour occurs gradually through the progressive steps of pre-contemplation, contemplation, preparation, action, maintenance, and termination (Motl, 2014). The SOC essentially defines one's readiness for behaviour change beginning with

pre-contemplation (when the individual has not considered any behaviour change), to considering a behaviour change (contemplation), preparing to commit oneself to the behaviour change, actionable activity initiating the behaviour change, maintaining the behaviour change and ending with termination wherein the new behaviour has become the norm. Fish' n' Steps (Lin et al., 2006), an interactive computer game investigated the TTM model in overcoming a sedentary lifestyle by encouraging participants to initiate PA where their daily step count led to the growth and activity of an animated character of a fish in a fish tank.

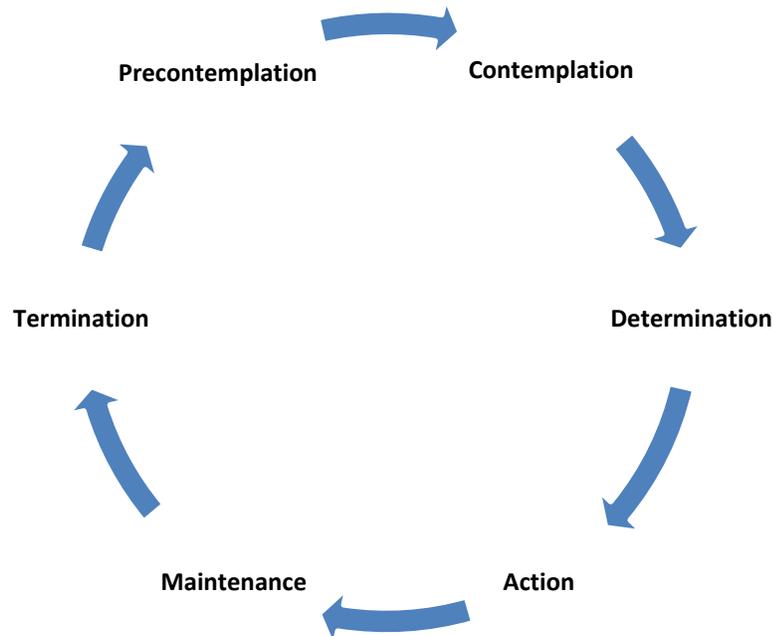


Figure 5: Transtheoretical Model (Stages of Change)

In this study, participants in the precontemplation stage indicated less number of steps compared to those in the termination stage, where the indicators of progression in the animated character of the fish contributed to maintaining their attitude towards increased step count (Lin et al., 2006).

Fogg Behaviour Model (FBM)

In the design of persuasive technologies, the combination of motivation, ability and trigger (Fogg, 2009) (Figure 6) needs to be present for a behaviour change to occur. This implies that an absence of any one of these will prevent the occurrence of an actionable behaviour. While this model has been studied in the design of persuasive technologies and referenced this model in this section from the perspective of the design of gamification applications. The aim of gamification

strategies is to persuade and encourage users to initiate and maintain PA, thereby serving as a trigger and fostering the motivation to be able to do the activity (J Hamari & Koivisto, 2013; Schoeppe et al., 2016).

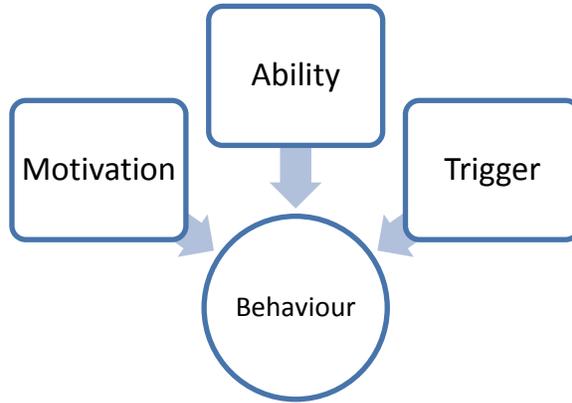


Figure 6: Fogg Behaviour Model (B = M+A+T)

Self Determination Theory (SDT)

SDT, an evolving theory of human motivation (Table 3), posits that for growth and personality integration, the three basic psychological needs of autonomy, competence and relatedness must be satisfied (R. M. Ryan & Deci, 2000a). Autonomy represents a sense of freedom or being in control, competence establishes a sense of ability to do things competently and, relatedness establishes a sense of association with others (R. M. Ryan & Deci, 2000a). SDT has been applied to video games (R. M. Ryan, Rigby, & Przybylski, 2006), which has shown that the perceived attractiveness of games is influenced by a player’s need satisfaction related to fulfilment of the psychological needs of autonomy, competence and relatedness. Within videogames and gamification, perceptions of competence and autonomy are also related to the intuitive nature of game controls and the sense of presence or immersion in the participants experiences (Kappen, Johannsmeier, et al., 2013; R. M. Ryan et al., 2006).

Basic Psychological Needs Theory		
Autonomy	Competence	Relatedness
Cognitive Evaluation Theory		
Intrinsic Motivation	Need for competence and autonomy	

Organismic Integration Theory					
Amotivation	Extrinsic Motivation				Intrinsic Motivation
Non-regulation	External Regulation (compliance, external rewards and punishment)	Introjected Regulation (self-control, ego-involvement, approval from others)	Identified Regulation (value of an activity, endorsement of goals)	Integrated Regulation (accepting of awareness, synthesis with the self)	Intrinsic Regulation (interest, enjoyment, inherent satisfaction)

Table 3: Self-Determination Theory (Deci, 2008; R. M. Ryan & Deci, 2000a)

In the context of SDT, intrinsic motivation refers to engaging in an activity because it is inherently interesting or enjoyable, and extrinsic motivation refers to doing something because it leads to a separable outcome (Deci, 2008; R. M. Ryan & Deci, 2000a). Cognitive Evaluation Theory (CET) posits that the need for competence and autonomy is rooted in intrinsic motivation. Intrinsic motivation could be influenced by social contextual and extrinsic factors such as rewards, praise, encouragement and feedback thereby fostering competence (R. M. Ryan & Deci, 2000a; R. M. Ryan et al., 1997). Additionally, these feelings of competence would not foster intrinsic motivation unless accompanied by a sense of autonomy (R. M. Ryan & Deci, 2000a). From an exercise motivation perspective, increased enjoyment and adherence in PA were associated with activities fostering intrinsic motivation elements of competence, challenges and social interaction (Edmunds et al., 2006; R. M. Ryan et al., 1997).

The Organismic Integration Theory (OIT) (Table 3) illustrates the taxonomy of extrinsic motivation and posits that people tend to internalise their experiences when being rewarded or externally motivated for participating in mundane or uninteresting activities (Deci, 2008; R. M. Ryan & Deci, 2000a). Within the context of gamification technologies for PA, I decided to focus on SDT because the primary research question aimed to identify whether gamification technology would foster intrinsic and extrinsic motivation in older adults?

The following sections gives an overview of persuasive technologies for PA motivation and gamification directed towards building the theory of *effective gamification*. SDT (Deci, 2008; R. M. Ryan & Deci, 2000a) was used as the foundational theory to develop the KEG (Kappen &

Nacke, 2013), which was eventually used to design a gamified PA technology tailored for the older adult demographic (Phase 3, Chapter 7).

3.2 Persuasive Technologies for PA Motivation

Persuasive technologies like exergames combine physical activity and exercise. Full-body movement exergames lead to behaviour change such as overcoming sedentariness and repeating activities, increased engagement, and participation in physical activity on the part of older adults' due to gesture-based interactions (Mandryk, Gerling, & Stanley, 2014). Gestures for selection and moving a cursor on the screen in place of mouse actions helped older adults in simplifying certain actions, encouraging physical activity and allowing for easier repetition of actions. The attitudes of older adults towards gesture-based interaction have changed, because of the presence of new products like the Nintendo Wii Remote and the Microsoft Xbox Kinect sensor. The performance and acceptance of freehand gestures through a variety of techniques were investigated in a study of 24 older adults that particularly looked at performance issues of several implemented freehand gesture techniques related to the control of a TV menu (Bobeth et al., 2012). This study explored gesture-based TV control methods instead of a standard hand-held remote to investigate controlling the TV through gestures as a form of physical activity. Transferring tracked hand movements to control a cursor on a TV was shown to be a positive approach for older adults (Bobeth et al., 2012). However, we still do not know whether full-body gestures as a way of interaction would increase the cognitive load on older adults because they would have to remember more items. In digital games, we need to prioritize capability before mechanics to make games more accessible to a larger audience, including older adults (Gerling, Livingston, Nacke, & Mandryk, 2012b). Meanwhile, robot games encouraging older adults to imitate movements of a mobile robot have developed into a persuasive tool for promoting PA among older adults (Hansen, 2011). This study investigated the learning of a robot and its adaptability to older adult players with differing degrees of challenged mobility. Changes in the interactions between older adults and the mobile robot, the former using required assistive tools such as crutches, wheelchairs, or walkers also provided information on play styles. Adaptable gameplay and controls, as well as adjustable calibration parameters in digital games for physical

therapy, were found to be critical in developing games for older adults with motor disabilities (Geurts et al., 2011).

Improved sense of physical, social and psychological well-being in older women resulted from the use of Nintendo Wii video games because of increased confidence in using technology, the benefits of improved connectedness with family members, and positive changes to their self-image (Wollersheim et al., 2010). Feedback on gesture-based games features higher ratings for physical well-being among older adults because of the intuitiveness of the games, the ease of the gestures themselves, and the increased movement demanded by the games (Rice et al., 2011). Studies using Nintendo Wii Fit Balance Board games indicated improvements in balance among older adults (Young, Ferguson, Brault, & Craig, 2010). The independently created *SilverBalance* exertion game using the Nintendo Wii Fit Balance Board reported positive engagement and enjoyment amongst older adults because of improvements in self-efficacy and the perception of the game's user-friendliness (Gerling, Schild, & Masuch, 2011).

Encouraging older adults to participate in physical activity through persuasive technology interventions provides the additional benefit of being able to track user activity. One study showed that overcoming sedentary lifestyles can be achieved through systems like *UbiFit Garden* (Consolvo et al., 2008) where the authors used on-body sensing and machine learning to track physical activity. The authors incorporated rewards and tracking functions to encourage older adults to participate in physical activity. A separate study (Albaina et al., 2009), used *Flowie*, a persuasive virtual coaching game, to encourage physical activity in the elderly by encouraging them to walk using motivational cues. Other researchers (Fan et al., 2012) found that overcoming barriers to physical activity through technology interventions must support the needs of older adults. The authors identified awareness of personal limitations, social motivation, establishing and adapting to routines, and finding enjoyable activities to be four consistent themes that technology interventions could address to help older adults overcome barriers to physical activity. *SilverPromenade*, a custom-video game which simulated real-life activities indicated that the simplicity of games and interactions are key drivers when designing for cognitive and physical limitations of older adults (Gerling, Schulte, et al., 2012). One study found that social exergaming was an effective strategy to engage older adults in physical activity,

and helped to reduce loneliness by promoting social interaction (Brox, Fernandez-Luque, Evertsen, & González-Hernández, 2011).

By the same token, persuasive technology games can be used as interventions to treat cognitive challenges therapeutically. Some of the many examples of this genre are games for people with dementia (Astell, 2010), games to enhance brain fitness in senior citizens (R.M. Baecker et al., 2010), games used to understand social disengagement (Bassuk, Glass, & Berkman, 1999), and games used to improve social interactions (Casey, Kirman, & Rowland, 2007). Exergames which combines PA and gaming technology (Juho Hamari & Koivisto, 2015b; Kappen, Mirza-Babaei, & Nacke, 2017), a form of persuasive technology (Chen et al., 2014; J Hamari, Koivisto, & Pakkanen, 2014) also helped with temporary improvements in concentration (Gao & Mandryk, 2012). While the above have contributed to behaviour change strategies in influencing older adult's PA, I examined gamified PA interventions from the standpoint of TPB (Ajzen, 2015; Motalebi et al., 2014) and SDT (R. M. Ryan & Deci, 2000a) to deconstruct the gamification layer in the design of these technology artifacts. The next section discusses the theoretical construct of gamification and associated terminologies.

3.3 Gamification

Gamification uses motivation theories like TPB (Juho Hamari & Koivisto, 2015b; Motalebi et al., 2014), TTM (Ferron & Massa, 2013; Lin et al., 2006; Müller & Khoo, 2014), SCT (Lister et al., 2014; Yoganathan, 2015), FBM (Orji, 2017; Wong, Kong, Kwok, & Kong, 2016; Zuckerman & Gal-Oz, 2014) and SDT (Kappen, Johannsmeier, et al., 2013; Lieberoth, 2015; Wong et al., 2016; Zuckerman & Gal-Oz, 2014) as few examples, to influence human behaviour, and it can make mundane tasks more *playful* (Flatla, Gutwin, Nacke, Bateman, & Mandryk, 2011). Playful systems incorporate aspects of fun, motivation (intrinsic and extrinsic), challenge, and experience (Boberg, Karapanos, Holopainen, & Lucero, 2015; L. Eklund, 2012). Gamification, by one definition, is the application of game design elements in non-game contexts (Deterding, Sicart, et al., 2011). Deterding et al. (Deterding, Sicart, et al., 2011) proposed that design elements be distinguished on five levels: 1) game interface design, 2) game design patterns and mechanics, 3) game design principles and heuristics, 4) game models, and 5) game design methods. While these levels aim to establish what the definition of various game design elements are, they are broad categorizations. A more specific definition of game design elements would

allow us to identify the actions needed to turn a business application into a gamified application. A taxonomy of these game elements as adapted from Deterding et al. (Deterding, Dixon, et al., 2011), is shown in Table 4.

Level	Description	Example
Game interface design patterns	Common, successful interaction design components and design solutions for a known problem in a context, including prototypical implementations	Badge, leaderboard, level
Game design patterns and mechanics	Commonly reoccurring parts of the design of a game that concern gameplay	Time constraint, limited resources, turns
Game design principles and heuristics	Evaluative guidelines to approach a design problem or analyze a given design solution	Enduring play, clear goals, variety of game styles
Game models	Conceptual models of the components of games or game experience	MDA; challenge, fantasy, curiosity; game design atoms
Game design methods	Game design-specific practices and processes	Playtesting, playcentric design, value conscious game design

Table 4: Levels of Game Elements. Adapted from Deterding et al. (Deterding, Dixon, et al., 2011)

Gameful design essentially means the incorporation of game elements in a non-game context to afford motivating and enjoyable experiences similar to gameplay in a digital gaming environment (Deterding, 2013). Such usage of specific game elements in non-game contexts were also used interchangeably with the term *gamification elements* (Allam et al., 2015; Edwards et al., 2016; Lister et al., 2014; Payne et al., 2015). A preliminary taxonomy of *gamification elements* distinguished game elements based on intrinsic incentives (curiosity, challenge, entertainment, social reward/peer pressure, personal returns and societal returns), extrinsic incentives (deals/discounts, financial rewards, goods/services, time, lottery, virtual currency, and record of achievement), resources and constraints (contextual and temporal), and feedback and status information (Robinson & Bellotti, 2013).

Many organizations, including social networking companies which are not traditionally dedicated to game development, have adopted gamification as a construct to create business, social, and training applications (Caponetto, Earp, & Ott, 2014; Huotari & Hamari, 2012; Raftopoulos, Walz, & Greuter, 2015; Seaborn & Fels, 2014). Plantville, developed by Siemens

(Johnson Andrea, 2012), provided a plant management simulation (a gamified app for training) that allowed 23,000 of their engineers to become familiar with plant design, operations, and maintenance procedures through a gamified application. The use of game elements in such a training type gamified app helped to maintain the interest of their engineers and helped to engage them over prolonged periods of time (Johnson Andrea, 2012). IBM Corporation developed CityOne (VanHemert, 2010), a gamified application to address problems such as overcrowding, inefficient energy infrastructure, or an economy with a stagnant small-business sector, thus exposing players to realistic challenges faced by actual municipalities. This helped users (players) to become more conscious about energy efficiency with greater accountability (VanHemert, 2010). However, developers of gamified business applications face the challenge of creating motivating gameplay strategies and creative design techniques to deliver subject matter not typically associated with games in a playful way.

Researchers have provided various definitions of the term “gamification”, discussed its relevance to industries that have adopted the concept of gamification, and explored the addition of fun, challenge, and motivation into many decision-making strategies (Hakulinen, Auvinen, & Korhonen, 2013; T. Tong, Chignell, & Sieminowski, 2015; Williams, 2014). Deterding explored user engagement with an application or service by making it more “fun” to use (Deterding, 2011). The theories of situated motivational affordances which represents the relation between features of the artifact and the actionable properties for the user based on the context of use (Deterding, 2011) and situational relevance which represents the importance of the non-game context to the user from an intrinsic perspective (Nicholson, 2012) reflect the criticality of player motivation in these contexts for gamifying applications. Many more definitions of gamification have been coined by researchers, and are presented in Appendix 13.3. In the context of PA, researchers have called for the need to incorporate the aspect of “fun” to make such activities more playful and engaging (Bekker, Sturm, & Eggen, 2009; Boschman, 2010; Health, 2016; Tseklevs et al., 2014; Yoon, Oishi, Nawyn, Kobayashi, & Gupta, 2004). With the advent of mobile technologies such as smartphones and digital apps, the process of remembering information has become more automated (Kappen, Johannsmeier, et al., 2013). Applying gamification to routine tasks, fitness schedules and reminders for activities proved to be useful to the players who were more engaged in the gamified task-management apps compared to regular

task managers due to the presence of avatars and reward systems (Kappen, Johannsmeier, et al., 2013). Dietary planning in a gamified manner using goals and reward systems motivated users to participate and engage in setting attainable goals and objectives for themselves (Schoeppe et al., 2016). However, as game designers, we lack a framework that allows us to clarify our designs for influencing behavioural change from the perspective of *effective gamification*.

Currently, we lack models that define attributes of effective gamification (e.g. what drives people to engage with a non-game application effectively). Therefore, in the following section, I explain my *effective gamification* design and analysis tool: *The Kaleidoscope of Effective Gamification* (KEG) (Kappen & Nacke, 2013).

3.4 Designing Effectiveness

Researchers have investigated different methods to identify questionnaires, heuristics, and game experience models as a means of evaluating the *effectiveness*¹⁰ of games. These methods use measures that approximate the emotional characteristics of players or categorize attributes of the game. Aparicio et al. (Aparicio, Vela, Sánchez, & Montes, 2012) examined a four-step iterative sequence of activities to perform the gamification process: 1) identification of the main objective; 2) identification of a transversal objective; 3) selection of game mechanics; and 4) analysis of effectiveness. They proposed determining the effectiveness of gamification by comparing before and after values of quality parameters using the service quality model (Spreng, Spreng, & Lansing, 1996), which integrates customer satisfaction and quality of service.

Based on the constructs of the SDT, needs satisfaction can take the form of intrinsic motivations and extrinsic motivations. Facilitating internalization (Deci et al., 1994a) also serves as a strong catalyst to engaging with a gamified application. However, the expectation of extrinsic rewards marginalizes intrinsic motivation (Deci, Koestner, & Ryan, 1999), (R. M. Ryan & Deci, 2000a). Categorization of intrinsic motivation further into autonomy, competence, and relatedness (R. M.

¹⁰ The notion of *effectiveness* seems to be somewhat misplaced at first when talking about games, where activities are more about engagement than productivity. However, in this context, we understand effectiveness as the successful engagement of a player through effective game design.

Ryan et al., 2006) helps to identify motivational characteristics from a need satisfaction perspective.

Key components of the human experience are interaction, play, having fun together, curiosity, and indulging in competitiveness or social collaboration. I propose the following definition for effective gamification:

Effective gamification is influencing human behaviour through engaging experiences, using game design principles in non-game applications and services. (Kappen & Nacke, 2013).

I designed the KEG (Section 3.5), which was defined as a behaviour change influencer to provide design guidelines for effective gamification (Kappen & Nacke, 2013) using SDT as the psychological construct for gamification. Detailed explanation and development of the KEG model (Kappen & Nacke, 2013) is presented in the following sections.

3.5 An Effective Gamification Model

As a starting point for my discussion on effective gamification, I examined a number of models in the following analysis. The mechanics-dynamics-aesthetics (MDA) (Hunicke, Leblanc, & Zubek, 2004) framework (a design-centric model) qualified the amalgamation of rules, the game system, and “fun”, where “fun” was the emotional response conforming to aesthetics. This model established the relationship between designer intent and player experience. However, designers were in need of clearer action guidelines for game design. Filling this gap, game design lenses (Schell, 2009) established a set of heuristics to enable game designers to create purposeful and engaging games. In the same context, Daniel Cook’s skill atoms¹¹ formed the basic ingredients for creating a systemic interaction between game process design elements. I refer to the term *game design process* for this because the relationship between systems is a *process* in itself. On a

¹¹ http://www.gamasutra.com/view/feature/1524/the_chemistry_of_game_design.php

linear hierarchical format, this combined model indicating these elements can be represented as shown in Figure 7.

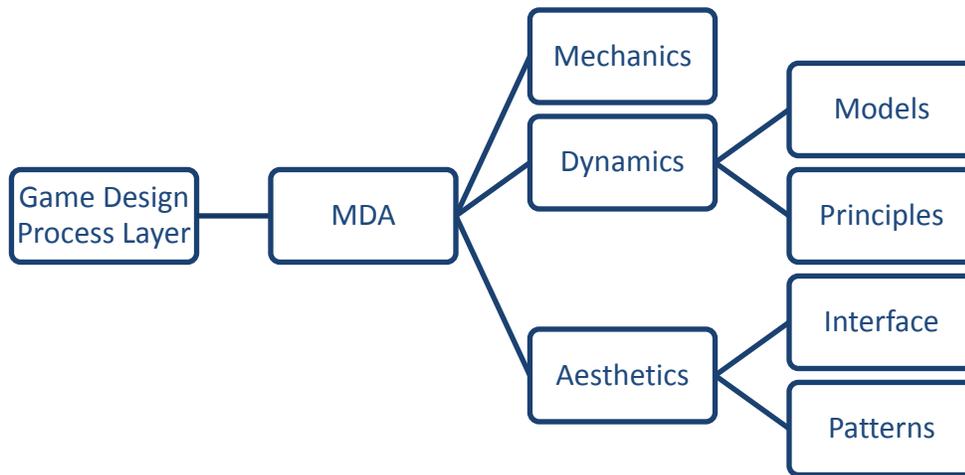


Figure 7: Game Design Process Layer ((Hunicke et al., 2004; Schell, 2009))

When designing a gameplay experience with intrinsic and extrinsic stimuli as a focus, the designer must integrate actions, challenges (Heintz, 2012) and achievements (Juho Hamari & Eranti, 2011) in the gamification design process. This would enable the creation of an engaging gameplay experience in a “gamified” application. The user experience derived in this layer is called the *game experience layer* (Figure 8). Based on prior definition, goals represent an end state of achievement, actions represent steps taken to reach goals, challenges represent inherent tasks or obstacles within the system on the path to achieving said goals, and achievement represents the act of reaching ones goal (Deterding, 2013).

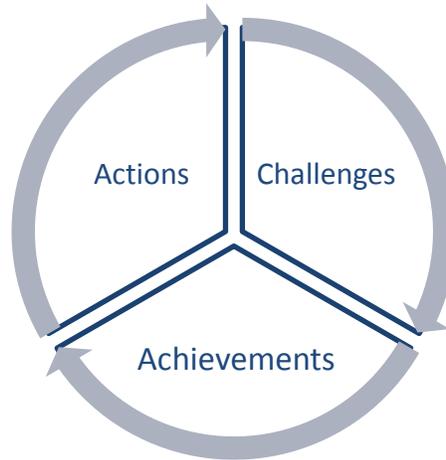


Figure 8: Game Experience Layer ((Juho Hamari & Eranti, 2011; Heintz, 2012))

The motivational model of video game engagement (Przybylski, Rigby, & Ryan, 2010) (a psychological model) discussed the relationship between player need satisfaction and player motives. The paper compared player need *satisfaction* elements (i.e., competence, autonomy, and relatedness (R. M. Ryan & Deci, 2000a)) to in-game motivational elements (achievement, socialization, and immersion) [110]. More specifically, the impact of achievements on player behaviour was investigated by the game achievement framework (Juho Hamari & Eranti, 2011) (an economical model), defining achievements as a sequence of signifiers, completion logics, and rewards. Therefore, the motivated behaviour layer (Figure 9) comprised of intrinsic and extrinsic factors contributing to the motivation for the user to play the app or the non-game system.

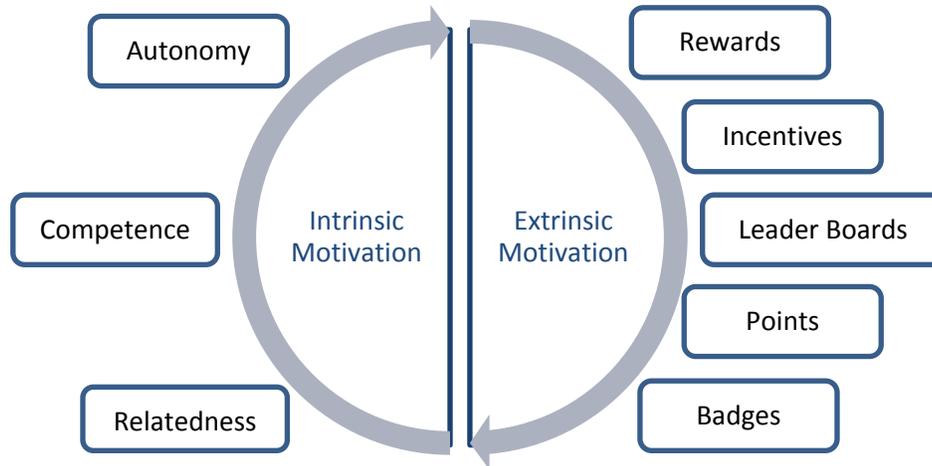


Figure 9: Motivated Behaviour Layer

For the purposes of simplicity, the illustration of this layer (Figure 9) represents a 50% distribution for intrinsic and extrinsic motivation, which may not be the case and much research is needed to establish if there is a relevant ratio for these two dimensions. The extrinsic motivation elements were selected based on the most commonly used gamification elements in this construct (Deterding, 2013; Juho Hamari et al., 2014; Mekler, Br, Opwis, & Tuch, 2013).

Based on the layers shown above, I proposed a cumulative model in development for “effective gamification” based on Ryan et al. (R. M. Ryan & Deci, 2000a); Deterding et al. (Deterding, Sicart, et al., 2011); Przybylski et al. (Przybylski et al., 2010); and Hamari et al. (Juho Hamari & Eranti, 2011), with the addition of the “*perceived layer of fun*”, which comprises assimilated game design process elements to influence human behaviour through the incorporation of actions, challenges, and achievements. The representation of the framework was redesigned to establish a circular arrangement of the dimensions and elements to express the simplification of the complexity of the decision-making process, metaphorically similar to the visual complexity to ordered patterns in a kaleidoscope.

This model illustrates the interconnectedness of behavioural change through gamification elements. In this model, the *layers of effective gamification*—I use the term “layers” as analogous to the layers of an onion—converge to a central *core*. The model interspaces behavioural change at its core, where intrinsic and extrinsic motivations—being drivers for gameplay behaviour in different ratios—are both relevant for effective gamification.

Figure 13 establishes the complexity of interrelationship between rings, with the adjacent rings in a top-view relationship. Each layer is explained below, starting from the central core of the KEG model.

Effective Gamification Core. This core establishes the nucleus of player experience, relating to all successive model layers. It represents the core objectives of a design enabling effective gamification. To achieve effective gamification, a game designer entrusted with the task of gamification of an application or a service must aim for an optimum player experience (L. E. Nacke, Drachen, & Göbel, 2010) leading to effective gamification. These represent the objectives of a design brief where satisfying the motivation driving the needs and wants (*Motivated Behaviour Layer*) of the user converge to enable effective gamification.

Motivated Behaviour Layer. A game designer moves outward from this layer, in which they have to identify a user need that grounds an intrinsic and extrinsic motivation. The influencers of the intrinsic motivation category of this layer consist of competence, autonomy, and relatedness (R. M. Ryan & Deci, 2000a) as shown in Figure 10. The influencers of the extrinsic motivation portion of this layer are composed of badges, points, leaderboards (Deterding, Sicart, et al., 2011), and rewards. This motivational behavioural influencer drives the next ring, the *Game Experience Layer*.

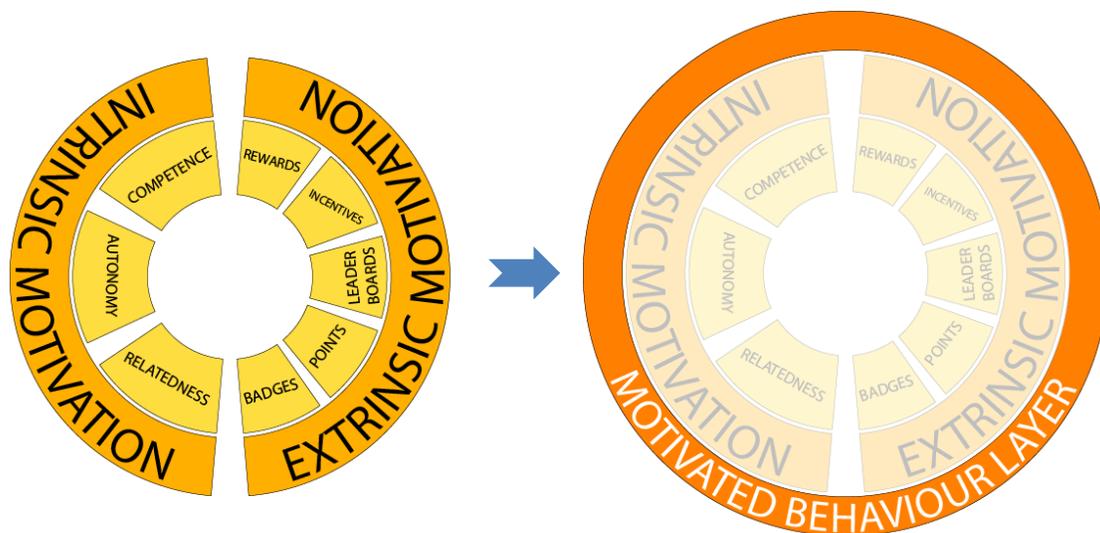


Figure 10: Motivated Behaviour Layer in the Illustration Format

Game Experience Layer. When designing a gameplay experience with intrinsic and extrinsic motivational stimuli as a focus, the designer integrates actions, challenges (Heintz, 2012), and achievements (Juho Hamari & Eranti, 2011) in the gamification design process (Figure 11). This would enable the creation of an engaging gameplay experience in a “gamified” application. The user experience derived in this layer is dependent on the next ring, called the *Game Design Process Layer*.

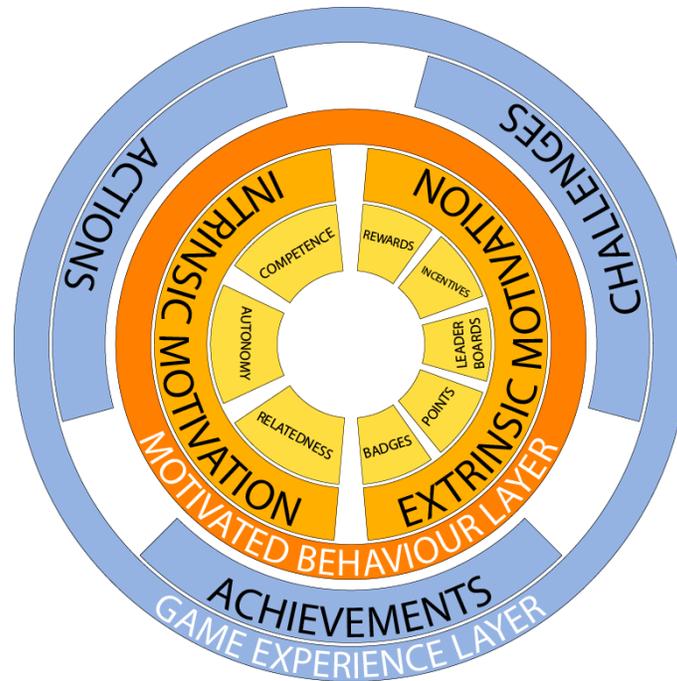


Figure 11: Game Experience Layer (GEL) with the Motivated Behaviour Layer (MBL)

Game Design Process Layer. Instead of using the term game design elements (Deterding, Sicart, et al., 2011), I refer to this ring as the *Game Design Process Layer* (Figure 12). The elements in this ring serve as subsystems or lenses (Schell, 2009). Integrating these subsystems to create a *fun* experience for the user makes it necessary to identify this layer as a *process*. Game design principles, mechanics, models, patterns, and interface design elements (Deterding,

Sicart, et al., 2011) serve as related sub-systems supporting this layer since they were designed to relate to the *Game Experience Layer*.

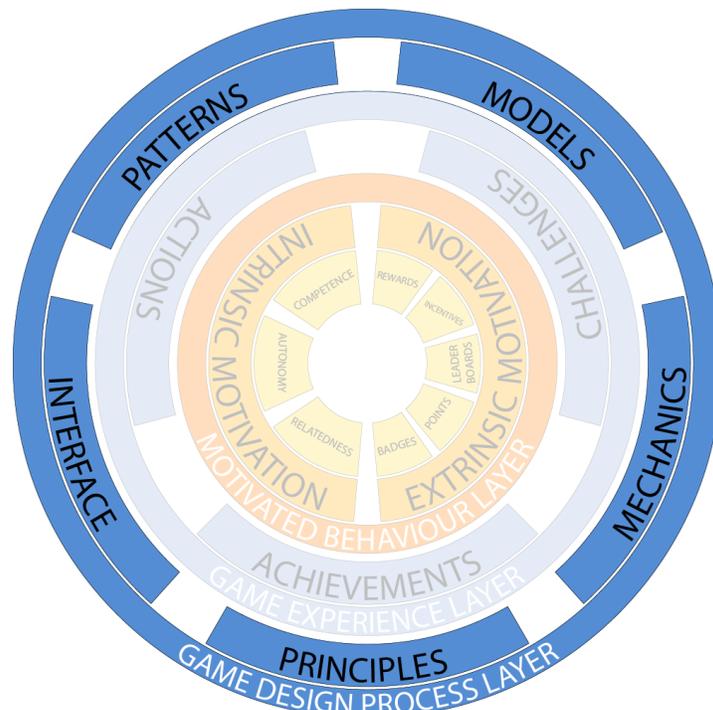


Figure 12: Game Process Layer with MBL and GPL

Finally, all these layers interact together to form the Kaleidoscope of Effective Gamification (Kappen & Nacke, 2013), an iterative and layered model as shown in Figure 13.

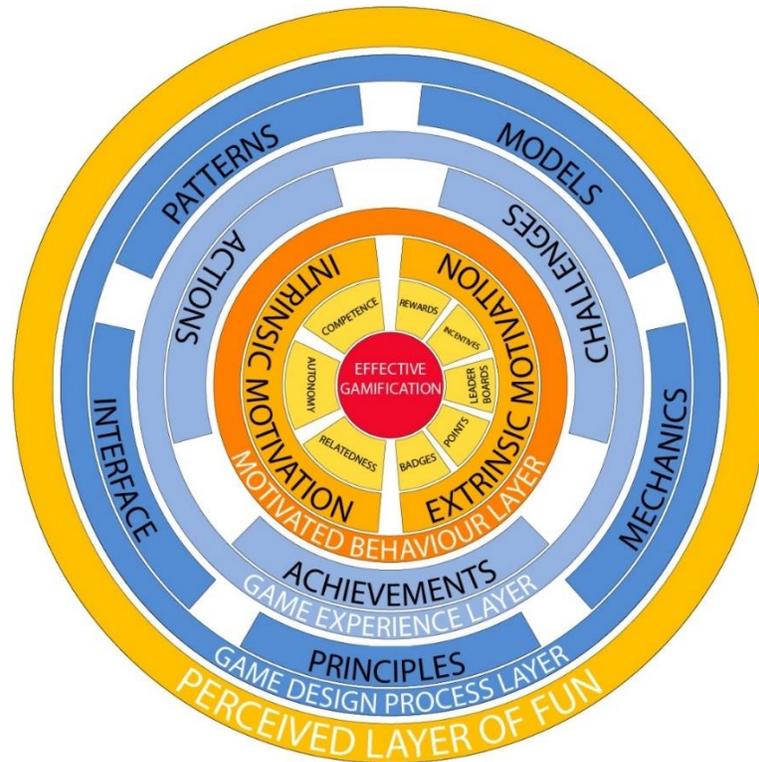


Figure 13: Kaleidoscope of Effective Gamification (KEG) Model

Figure 14 shows the player viewpoint and the designer viewpoint of the gamification app necessary to build an effective gamification application. From the player's perspective, unless there is a fun element which caters to their intrinsic motivations while engaging themselves in a mundane non-game application, it would be difficult to gain their attention and retain their interest in the gamified application.

Perceived Layer of Fun. This ring, the outermost layer, has a synergetic converging relationship with the innermost Motivated Behaviour Layer. Intrinsic motivation is a major influence for users to engage with a non-game application. A player progresses from the outermost ring, the *Perceived Layer of Fun*, which is what a player can see and aesthetically experience in terms of audio, visuals, interface design, tangible interactions, and intangible experiences. These experiences converge during gameplay through actions, challenges, and achievements that engage the player. Unless the player experiences motivation through a feeling of delight or fun when playing the game system, the gamification is not effective. This is my understanding of the

perceived layer of fun used in gamification practice and literature. The interactive and potentially immersive nature of gamified applications—that involves actions, challenges, and rewards—with the injection of “*fun*” —provides motivation to explore these applications (Kappen & Nacke, 2013).

A player, on the other hand, progresses from the outermost ring, the *perceived layer of fun*, which is what a player can see and experience in terms of audio, visuals, interface design, tangible interactions (game design process layer) and intangible experiences. These experiences (game experience layer) are assimilated into a gameplay through actions, challenges (Heintz, 2012) and achievements (Juho Hamari & Eranti, 2011) which encourages the player to be engaged in the game, influencing a motivated behaviour of the player. Unless the player experiences motivation through fun to play the game system, there is no effective gamification.

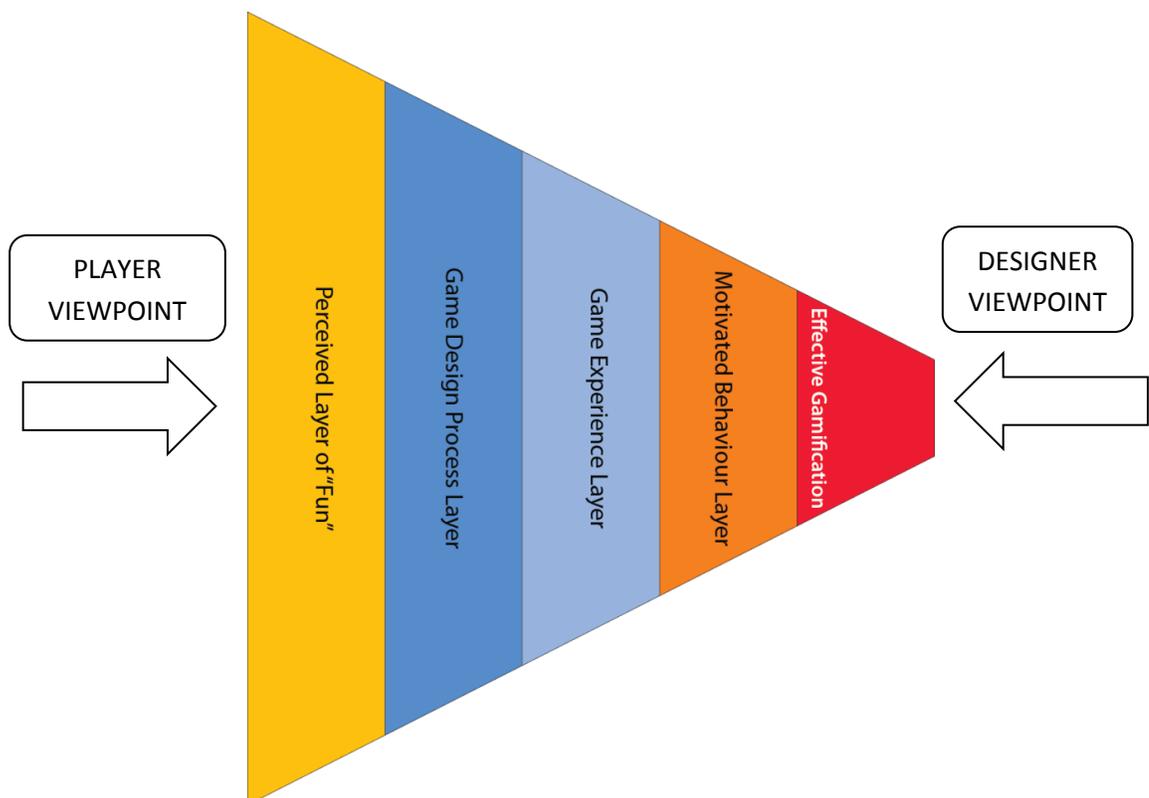


Figure 14: Player-Designer Vantage Point

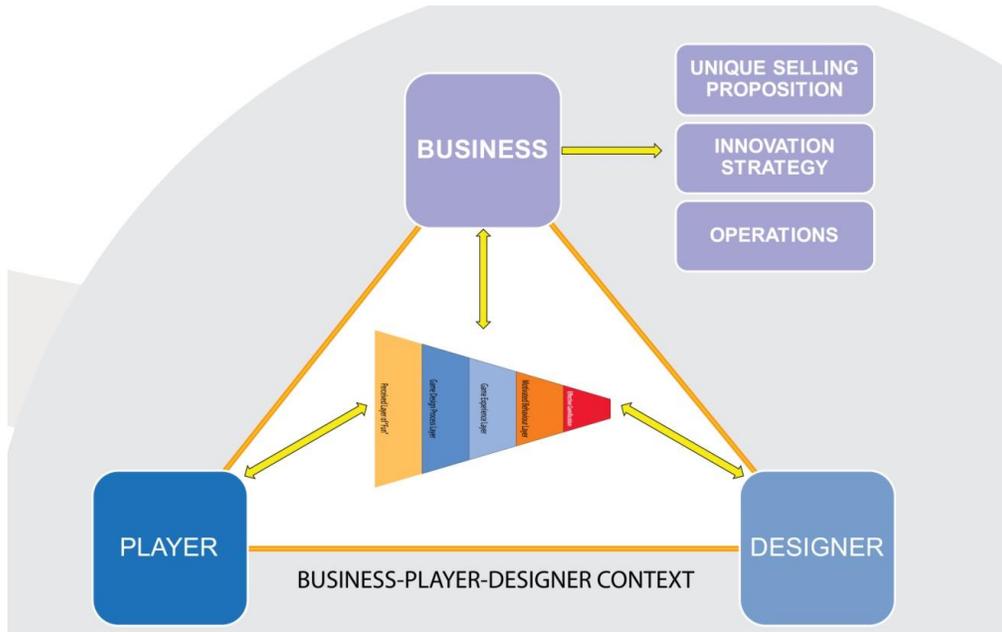


Figure 15: Business Model using KEG

Figure 15 illustrates a hypothetical interrelationship of how the KEG design model could be used with reference to establishing a unique selling proposition, innovation strategy and advertising operation for the application.

For effective gamification, however, I reproduce the following design guidelines which focussed on the design layers of my KEG model (Kappen & Nacke, 2013).

Ring-Layer	Attribute	Guideline
Motivated Behaviour Layer	Intrinsic Motivation	Autonomy: Evaluate the needs to the demographic profile to identify values of personal importance to users such that their commitments to activities are internalized.
	Intrinsic Motivation	Competence: Identify core values which enable users to enhance their capabilities and skills.
	Intrinsic Motivation	Relatedness: Create the possibility of social connectedness, acceptance and validation within the gamification application.
	Extrinsic Motivation	Badges, points, leaderboards, incentives and rewards are only of limited value. While your app can have these extrinsic motivation elements, ensure that there is an experience of “fun” and the element of surprise in

		procuring these elements. Tagging along these elements for the sake of a reward will have no value addition to the gamification application. Aesthetic representation is another important factor attached to these rewards.
Game Experience Layer	Actions	Identify game mechanics, such as rules to stimulate intrinsic motivation of the user, strategies to indulge the user in getting excited about gameplay, and sustaining their interest throughout the game’s duration. All these sub-systems must integrate well with the motivated behaviour layer.
	Challenges	Ensure that the rules identifying the game mechanics are relevant to the intrinsic motivation elements so that the drive to continue playing the gamification application is based on the user’s internal desires and aspirations.
	Achievements	Identify goals and objectives within the game that enhance the personal goals of the user and ensure its conformance to the motivated behaviour layer.
Game Design Process Layer	Interface, Mechanics, Models, Principles	Identify goals within each subsystem to maximize the process of integrating subsystems to create a fun experience for the user, while ensuring motivation.
Perceived Layer of “Fun”	“Fun”	Identify <i>the perceived layer of “fun”</i> , such as excitable attributes, elements of surprise characteristics, fun in accomplishing milestones and the use of exciting hypermedia effects. These would influence and motivate the behaviour of the user through experiential and memorable gameplay of the gamification application.

Table 5: Design Guidelines for Effective Gamification (Kappen & Nacke, 2013)

The “Perceived Layer of Fun” becomes a critical aspect of any gamification application, because this is the layer that the users experience. This layer must establish a close relationship with the motivational behaviour layer. The Game Design Process Layer must create memorable and “fun” experiences, which add value to the gamification process.

The KEG model represents an initial checklist of objectives that define integrated relationships between elements on each layer, which in turn establish vertical, three-dimensional relationships with the layers directly above and below. Thus, the framework demonstrates system relations between all layers. It also works as a design tool for game designers that need to gamify business apps and services as indicated in Figure 15. I validated these design guidelines by applying it to the development of a fitness application (Phase 3) and the study of motivations pertaining to PA engagement.

3.6 Summary

Regular PA and routine exercise is a chore for many. It is boring and lacks the excitement in comparison to a gaming activity or an exergame. This chapter outlined behaviour change theoretical frameworks and explained how persuasive technology like gamification that can be used as behaviour change agents for PA motivation. While exergames are popular among different age groups, these are full-fledged interactive digital games designed to track and react with body movements. However, the goal of this dissertation was not to build an exergame or gaming system but to investigate how PA motivation of older adults could be facilitated through gamification elements to make daily PA activity and routine exercise to be a fun-filled experiential activity. This chapter illustrated the design and build of the KEG framework, a design and analysis tool, which was used to build a gamified system tailored for older adults considering their barriers to PA and current health conditions. The design of this technology is outlined in Chapter 7 (Phase 3).

Chapter 4

4 Research Methodology

This chapter explains the research methodology and method used to investigate intrinsic and extrinsic motivations of older adults for PA using gamified technology. To achieve this, the research investigation process was influenced by the iterative Design Science Research methodology (DSR). DSR involves the creation of new knowledge through the design of new or innovative artifacts, analysis of the use and performance of these artifacts to improve information systems (Vaishnavi & Kuechler, 2013). While staying physically active is essential to wellbeing later in life, many older adults experience physical and mental barriers to PA. Past research (Gardner et al., 2014; Irvine et al., 2013) has investigated the development of interactive systems to support exercise routines and reduce access barriers. Traditional or classic PA applications have been used as an intervention to promote PA among older adults'. However, little research has been conducted on the needs and preferences of older adults' regarding playful technologies that support PA. I have addressed this knowledge gap through an exploration of the motivation to exercise among older adults, grouped around theory based behaviour change interventions relevant to technology design.

Based on literature review presented in Chapter 3 (Section 3.1), behaviour change theory-based PA interventions have been known to increase participants' motivation, outlook and attitudes towards working out and PA (Ajzen, 2015; Bandura, 2015; Glanz, 2015; Janz & Becker, 1984). Prior research has not compared the differences in the effectiveness of traditional PA interventions (A. C. King, 2001; A. C. King et al., 1998; Weber & Sharma, 2011) contrasted with web-based PA interventions (Irvine et al., 2013; Nigg, 2003; Rejeski et al., 2008) or gaming technologies (Brox & Hernandez, 2011; Lin et al., 2006; Tabak, Dekker-van Weering, van Dijk, & Vollenbroek-Hutten, 2015; Thorsteinsen, Vittersø, & Svendsen, 2014a), and gamified interventions (Ahola et al., 2013; Cadmus-Bertram, Marcus, Patterson, Parker, & Morey, 2015; Kappen et al., 2016; Khot et al., 2013). A comparison between traditional PA interventions and gamified technologies (Section 2.5 and 2.6) indicated that engagement and fun aspects of gamified PA technologies encouraged younger participants to maintain their activities (Ahola et

al., 2013; Juho Hamari & Koivisto, 2015b; X. Tong et al., 2016; Zuckerman & Gal-Oz, 2014). While exergaming for seniors (65+) have indicated improvements with flexibility of the body (Brox et al., 2017), and usefulness of the technology to maintain PA (Bird et al., 2015; Brox & Hernandez, 2011; Smith et al., 2009), limited research is present with investigating gamification and physical activity for the older adult demographic (Health, 2016; Kappen et al., 2016; Silva, Holden, & Nii, 2014). Therefore, the investigation of gamified PA technology for older adults in this dissertation is critical from the generation of new knowledge.

Empirical research alone allows us to evaluate design artifacts quantitatively, but it does not provide the iterative framework that leads to the design of an artifact in the same way that DSR does. DSR (Vaishnavi & Kuechler, 2013) is, therefore, a well-suited research approach because it embraces the artifact creation as well as its iteration. Developing gamified PA interventions for older adults' presents the opportunity to create gamified technological artifacts to help older adults' in overcoming their sedentary lifestyles. Therefore, in my dissertation, I used the DSR (Vaishnavi & Kuechler, 2013) as the methodology for investigating the effectiveness of gamified PA interventions. The development of gamified technological interventions which is an artificial phenomenon, grounded on gamification framework (Kappen & Nacke, 2013) and empirical research qualifies for the DSR methodology.

4.1 Design Science Research Methodology

DSR investigates designing novel artifacts and analyzing these artifacts and their use through the lenses of design, analysis, reflection, and abstraction (Vaishnavi & Kuechler, 2013). The DSR methodology also involves the study of artificial phenomena designed to *extend* human and organizational capabilities (Hevner, March, Park, & Ram, 2004). This methodology has been used in past dissertations to design, evaluate and modulate technology artifacts using gamification strategies within the education domain (Walter, 2014) and research on using gamification in learning (Challco, Moreira, Bittencourt, Mizoguchi, & Isotani, 2015; Wongso, Rosmansyah, & Bandung, 2014) and information systems research (Peffer, Tuunanen, Rothenberger, & Chatterjee, 2007), to mention a few. This thesis specifically investigates the development of empirically grounded artifacts to create meaningful (Nicholson, 2012) and effective (Kappen & Nacke, 2013) gamified fitness applications for older adults'. Therefore, my thesis employs DSR as a methodology.

The intersection of the use of theory-based gamified PA interventions and DSR provides an effective platform for investigating how PA for older adults can be sustained through the iterative stages of DSR: problem awareness, suggestion, development evaluation, and conclusion (Vaishnavi & Kuechler, 2013). Additionally, the seven guidelines for DSR methodology are identified as follows: (1) design as an artifact, (2) problem relevance, (3) design evaluation, (4) research contributions, (5) research rigor, (6) design as a search process, and (7) communication of research (Hevner et al., 2004). Creating, modifying and evaluating artifacts (Hevner et al., 2004) (an important part in iterative DSR) are ways in which this thesis advances our knowledge about designing technology for older adults using DSR (Table 6). The DSR methodology calls for identifying the challenges and barriers preventing or impeding older adults from participating in PA. The intersection of KEG (Kappen & Nacke, 2013) and SDT (R. M. Ryan & Deci, 2000a) provided the analytical framework to evaluate a gamified technological artifact. It provided the guidelines through empirically grounded research contributions to be used by future researchers.

	DSR Guideline	Description	Gamified Artifact
1	Design as an Artifact	Design science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation	Development of an adaptive online artifact for fitness gamification (Spirit50.com).
2	Problem relevance	Develop technology-based solutions to solve important and relevant business problems	The artifact is customizable from the point of goals, barriers and current fitness health conditions of older adults.
3	Design evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.	Spirit50.com is evaluated from a usability, user performance and engagement standpoint (Section 4.6.4).
4	Research contributions	Effective design science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.	The fitness gamification artifact (Spirt50.com) was designed based on the superimposition of KEG (Kappen & Nacke, 2013) and SDT (R. M. Ryan & Deci, 2000a). This design strategy provides a new method for designing gamified fitness applications.
5	Research rigour	Relies on the application of rigorous methods in both the construction and evaluation of the design artifact.	The current Spirit50 artifact resulted from user evaluation testing. The first round of user evaluation was at CER involving five participants. The second round of user evaluation was conducted at Humber College and

			UOIT with one participant at each location. A final user experience evaluation study is indicated in the experimental study section (4.6.4).
6	Design as a search process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.	The challenges of participants in using the gamified artifact from the standpoint of usability, user performance and engagement has been evaluated as indicated in the experimental study section (4.6.4).
7	Communication of research	Design science research must be presented effectively to both technology-oriented and management-oriented audiences.	This dissertation is a medium of presenting the results of research investigation into adaptive engagement of older adults through a fitness gamification artifact.

Table 6: DSR Guidelines (adapted from (Hevner et al., 2004)) and comparison with Thesis constructs

4.2 Problem Definition

People in the age bracket of 50-70 years are generally keen on PA, but age-related challenges and impairments present barriers (Brauner et al., 2013) to their participation in a fitness program. Older adults face difficulties associated with overcoming a sedentary lifestyle. However, once they overcome these challenges, they could work on accomplishing their health and wellness goals. Here, I am specifically interested in identifying the fitness motivations of older adults who lead an active lifestyle. An active lifestyle (“Dietary Guidelines for Americans,” 2014) is defined as the ability to engage in activity equivalent to walking more than three miles per day, in addition, to independently carrying out normal daily activities. I refer to individuals living in this manner as *active lifestyles*. The thesis statement involved researching the needs and motivations of older adults engaged in fitness activities, identifying personality characteristics related to fitness gaming motivations, developing a needs-based personalized adaptive gamified online fitness application and designing a technology facilitated exercise motivation inventory. This development of playful technologies based on older adults’ motivations to engage in fitness activities would help in adaptive engagement of older adults’ in PA. It could also sustain their motivation while improving their health, and allow them to achieve their wellness goals.

4.3 Older Adults – A Working Definition

This section provides a summary of the terms used to identify adults in different age groups. From the stand point of this dissertation, it was important to identify a working definition for the sample population being investigated.

The United Nations defined adults aged 65 years and older as seniors or elderly (Kumashiro, 2000). The field of geriatrics classified persons aged 65 years and older as being in their senior years, and oldest -old adults to be aged 85 years and older (Chase, 2013; A. C. King, 2001; Kumashiro, 2000).

Many studies in the canon of research on PA qualified older adults to be persons aged 50 years and older. Based on literature, in King et al. defined older adults to be 50 years and older (A. C. King, 2001; A. C. King & King, 2010; A. C. King et al., 1998). Dacey et al. studied 645 participants (Mean age 63.8, SD 8.3), who were termed as older adults and the inclusion criteria for the sample population was above 50 years of age (M. Dacey et al., 2008). Older adults were also defined to be aged 50 years and older in studies on PA (Brawley et al., 2003; Imam et al., 2014; Denise A. Peels et al., 2012; Denise Astrid Peels et al., 2013; Rice et al., 2011; van Stralen et al., 2009). For these reasons, this dissertation focussed on the participant sample to be “older adults”, aged 50 years and older.

For the Phase 1 (Preliminary Studies – Chapter 5), participants were over 50 years of age. Based on the literature mentioned above, adults aged 65 years and older were also included in the older adult’s sample selection. Based on the study on gaming technology and adults by the PEW Research group (Jones & Fox, 2009), in Phase 2 (Survey Study – Chapter 6), the age differentiation of adults into different age groups was done as follows: 18-29 (G1 - younger adults), 30-49 (G2 - middle aged), 50-64 (G3 - older adults), and 65+ (G4 - Seniors). Therefore, I used “older adults” to be defined according to this age categorization to conduct my analysis. In Phase 3 (Spirit50 – Chapter 7), the gamified artifact was designed for adults aged 50 years and older. In Phase 4 (Experimental Study – Chapter 8) the participant sample selected were older adults aged 50 years and older. In Phase 5 (Expert Evaluation – Chapter 9), the heuristics

evaluation was also conducted using the older adults' definition to be adults aged 50 years and older.

4.4 Research Goals and Methods

There are major differences between the motivation of younger adults (Rice et al., 2013) and older adults (Motalebi et al., 2014) to keep fit. For the purposes of this research activity, I am interested in researching active older adults over 50 years of age.

Providing an aging population with an engaging fitness community and online service that is focused on their needs will allow aging Canadians to continue to live healthily at an older age and minimize deterioration of their cognitive and physical abilities (CSEP, 1999; Shields et al., 2010). This research provides novel technology that improves the quality of life in older adults.

Based on my prior qualitative research I have created a motivation-centric online fitness intervention artifact (Spirit50.com) catering to the fitness exercise plans for older adults. At this stage, I planned to conduct a survey questionnaire study of gamified PA (Section 4.6.2), an *experimental study session* focused on gamified PA interventions (Section 4.6.4), and *expert evaluation study* (Section 4.6.5) of guidelines for PA technology. Spirit50.com was a technology artifact for consideration because compared to existing PA technology, this was a gamified fitness activity intervention website designed for use by older adults.

From the intersection of motivations posited by SDT (R. M. Ryan & Deci, 2000a) and effective gamification (KEG) (Kappen & Nacke, 2013), I analyzed fitness activity data from mixed-method studies including interviews and focus group sessions to establish influencers for intrinsic and extrinsic motivation that helped older adults to engage with online technology. This analysis helped me define personality traits and motivational characteristics related to fitness activities for older adults. This, in turn, will help me customize and personalize digital games for them. I already evaluated (see Section 4.6.1: Qualitative Studies and Chapter 5: Section 5.5 - Results) the different motivations between people, who are already active when compared with non-active individuals and their drive to engage with gamified technology. This research resulted

in a full paper publication at the IEEE conference (Kappen et al., 2016). The studies that led to this contribution are outlined in the section on qualitative studies (4.6.1) and in Chapter 5.

My contribution to knowledge advancement currently is the investigation of motivational factors concerning engagement in PA for older adults through online technologies, using the KEG and SDT models as a design and analytical framework. This will serve as a predictor for social computing within these activities and technology that can help direct attention (Antikainen, 2011; Belchior et al., 2013), enable engagement, and retention in a successful fitness application for older adults. Furthermore, this dissertation resulted in the development of an *Exercise Motivation Technology Framework (EMTF)* (Chapter 5.6) for Older Adults.

4.5 Research Questions

Lister et al., (Lister et al., 2014) indicated the potential for gamification to change health behaviours. Furthermore, monthly meetings at Google Campus, London, to evolve strategies that influenced health behaviours was reported by King et al., indicating the collective aim to develop digital ‘games with purpose’ (D. King et al., 2013). While some research (Bolszak et al., 2014; M. Dacey et al., 2008) examines the intrinsic and extrinsic motivations of older adults to engage in physical activity, to the best of my knowledge, there has been no research conducted on the *engagement* of older adults in PA using *gamified* fitness applications as influencers of health behaviour.

4.5.1 Hypotheses

My hypotheses are rooted in established and validated studies which have investigated the following: the benefits of web based interventions to promote PA by sedentary older adults (Irvine et al., 2013); improved engagement of older adults with dementia when using artificially intelligent assistive technology (Leuty, Boger, Young, Hoey, & Mihailidis, 2013); improved motivational benefits of using a telehealth intervention using Nintendo Wii Fit Balance Boards (Imam et al., 2014); and changes in attitude towards individual health (Brauner et al., 2013).

Brawley et al. reported that self-monitoring was the behaviour modification strategy that led to maximum participation in PA (Brawley et al., 2003). Theory-based behaviour change methods

for motivating adults' in participating in PA, providing self-monitoring and socialising modifiers can be done using gamification strategies (Cadmus-Bertram et al., 2015; Edwards et al., 2016; J Hamari & Koivisto, 2013; Romero et al., 4392). The question is to investigate whether such strategies can be used to foster intrinsic and extrinsic motivation for older adults PA.

These studies provide evidence to support the usage of technology artifacts for PA challenges faced by older adults. My methodical approach is to leverage this evidence to investigate the effectiveness of *gamified* technology artifacts as influencers of health behaviour change for improving PA in older adults'. Because of this, my hypotheses are:

H0: If older adults use traditional or classic physical activity applications interventions, there is **no difference** as measured by **enjoyment and engagement** compared to when they use gamified physical activity applications to influence change in health behaviour.

H1: If older adults use traditional or classic physical activity applications interventions, they are **less engaged** as measured by **enjoyment and engagement** than when they use gamified physical activity applications to influence change in health behaviour.

H2: If older adults use traditional or classic physical activity applications interventions, they are **less motivated** than when they use gamified physical activity applications to influence change in health behaviour.

These hypotheses lead to the following primary and secondary research questions:

4.5.2 Primary Research Questions:

1. How can gamified technology be used by older adults to change their health and physical activity?
2. How can gamification be used as a health behaviour strategy to change motivation and engagement of older adults?

4.5.3 Secondary Research Questions:

SRQ1: Using SDT and KEG as a design lens, do changes in motivations of older adults facilitate fitness activity?

SRQ2: What are the underlying factors and challenges that facilitate or prevent fitness activities for older adults in the context of technology-supported PA?

SRQ3: What are the challenges and design strategies for designing motivated gamified physical fitness activities and applications?

4.6 Summary of Method used in the Phases

I used a mixed-method research investigation incorporating design science research methodology and studies with mixed-method studies. A simple flowchart of these methods is shown in Figure 16.

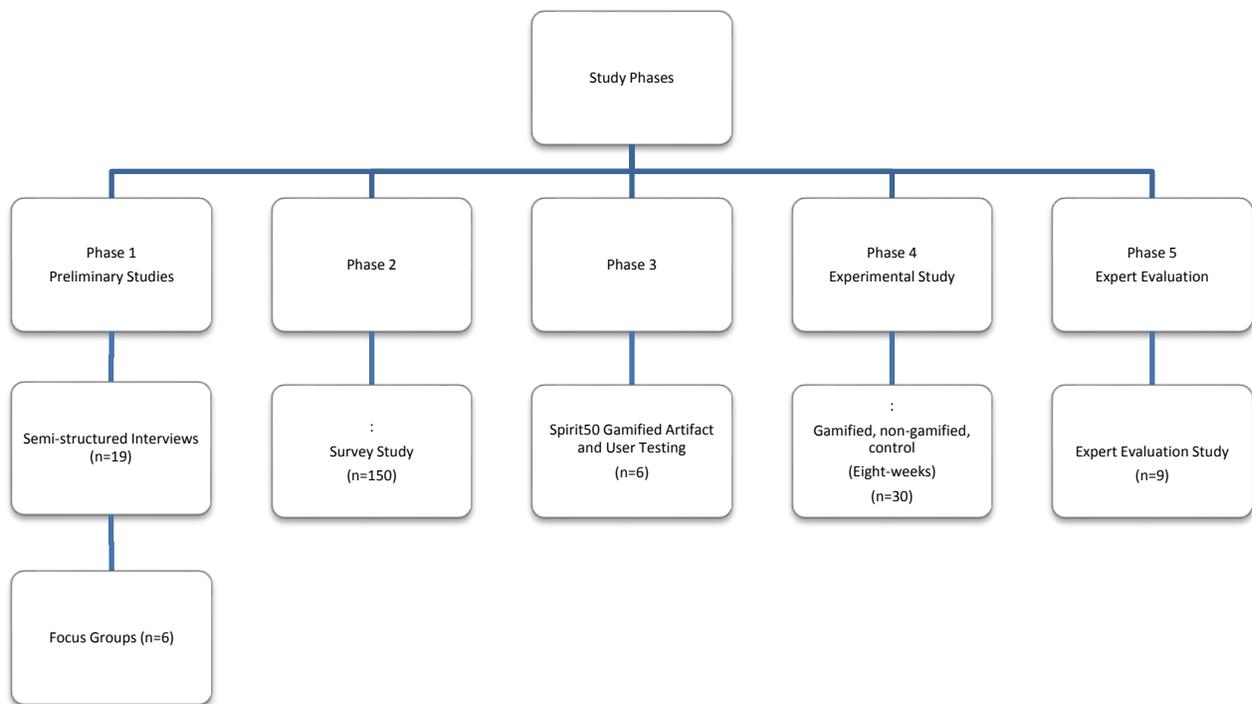


Figure 16: Flowchart of Investigative Method

4.6.1 Phase 1: Preliminary Studies

To investigate my primary and secondary research questions, a set of interviews with older adults and PA conducted by the Centre for Elder Research (CER), Sheridan College campus, was used for analysis. As a follow-up to the semi-structured interviews, I conducted a focus group session (Chapter 5).

4.6.2 Phase 2: Survey Study

I then conducted a survey study to evaluate and compare the PA motivation for younger adults and older adults using technology facilitated PA which is outlined below and detailed in separate chapters. The survey study helped to delineate older adults' preferences for PA motivation and motivational affordances between age groups as per the PEW age cohorts (Jones & Fox, 2009): 18-29 (G1 - younger adults), 30-49 (G2 - middle aged), 50-64 (G3 - older adults), and 65+ (G4 - Seniors)

This survey study was conducted to investigate the preferences of technology artifacts used for fitness and PA by individuals over the age of 50 when performing their daily PA routines. This study for the online survey is detailed in Chapter 6. From this study, it was also decided to focus on designing PA technology for adults over 50 years of age, which included adults/seniors over 65 years of age.

4.6.3 Phase 3: Spirit50 Design, Development and Testing

Spirit50 was a hands-on implementation of the research in the form of a web artifact, developed using the guidelines of the MBL layer from the KEG (Kappen & Nacke, 2013) model, which posits that the intrinsic motivations of players or users must drive the underlying purpose of any gamification strategy. In this case, internalized motivations for health and wellness were identified for a heterogeneous assemblage of older adult personalities. My detailed analysis of the qualitative data (Chapter 5) informed of the presence of intrinsic motivations and aspirations to maintain a healthy lifestyle in spite of age-related impairments. I decided to pursue the path of strategizing these internalized motivations for health and wellness to be the core of the effective gamification (Kappen & Nacke, 2013) strategy. Details of the application and user testing of the gamified application with participants and the procedure are indicated as Phase 3 in Chapter 7.

4.6.4 Phase 4: Experimental Study

Further to the survey study, an experimental study with active older adults over 50 years of age was conducted in the summer of 2016. This study is detailed in Chapter 8. Participants were randomized into Experimental Group 1, Experimental Group 2 and Control Group as shown in Table 7. This gave me a two-level independent variable (gamified vs non-gamified), and a control group, where I manipulated gamified and non-gamified levels of PA. As dependent variables, I measured the *motivation*, *enjoyment*, *engagement*, and *exercise performance* of older

adults when using these conditions. The explanation for the selection and validity of these instruments is given in the chapter on Phase 4 (Chapter 8).

Levels	Independent Variable	Dependent Variables and Measures	
1 Experimental Group1 (gamified)	Gamified Physical Activity Applications (Spirit50.com)	<ol style="list-style-type: none"> 1. Enjoyment 2. Engagement 3. Motivation 4. Exertion 	<ol style="list-style-type: none"> 1. Intrinsic Motivation Inventory (IMI) (McAuley et al., 1989; Mekler et al., 2014) 2. Psychological Need Satisfaction in Exercise (PNSE) (Wilson et al., 2006) 3. Follow-up Interviews 4. Perceived Rating of Exertion (RPE) (Borg, 1982; O’Hartaigh et al., 2014; Thorsteinsen, Vittersø, & Svendsen, 2014b)
2 Experimental Group 2 (non-gamified)	Non-Gamified Physical Activity Applications	<ol style="list-style-type: none"> 1. Enjoyment 2. Engagement 3. Motivation 4. Exertion 	<ol style="list-style-type: none"> 1. Intrinsic Motivation Inventory (IMI) 2. Psychological Need Satisfaction in Exercise (PNSE) 3. Follow-up Interviews 4. Perceived Rating of Exertion (RPE)
3 Control Group	Traditional Fitness Activity Interventions	<ol style="list-style-type: none"> 1. Enjoyment 2. Engagement 3. Motivation 4. Exertion 	<ol style="list-style-type: none"> 1. Intrinsic Motivation Inventory (IMI) 2. Psychological Need Satisfaction in Exercise (PNSE) 3. Follow-up Interviews 4. Perceived Rating of Exertion (RPE)

Table 7: Independent Variables and Dependent Variables

Table 7 indicates the independent and dependent variables to be measured in this experimental study using validated scales. Details of the participants and experimental protocol, risks and validation are indicated in Chapter 8.

4.6.5 Phase 5: Expert Evaluation

The use of expert evaluation of gamified PA artifacts (Spirit50) was done to determine the efficacy of the gamification elements and the Exercise Motivation Technology Framework (Section 5.6). These experts were specialists with a broad research base in the areas of gamification, health and wellness, HCI and older adults. This study is detailed out in Chapter 9.

4.7 Summary

This chapter outlined the DSR methodology used for the design, development, and user testing of Spirit50, a gamified PA technology for older adults. A summary of the method used to investigate the relevance of motivational affordances (gamification elements) to foster intrinsic and extrinsic motivations of older adults towards PA outlined a mixed-method, approach that consisted of five phases. To the best of my knowledge, no gamified application specifically designed for older adults PA was readily available in a commercial format for purchase. While Spirit50 was, a gamified technology developed during the course of this PhD research, this tool was used only as a medium to investigate motivational affordances to foster intrinsic and extrinsic motives for PA among older adults. The following chapters discusses each of the five phases in detail. Additionally, questionnaires and participant responses relevant to each phase is found in the appendix as indicated in its respective chapters.

Chapter 5

5 Phase 1: Preliminary Studies

Materials from this chapter have been published in a peer-reviewed conference proceeding and has been reproduced under License to use from IEEE (Appendix 13.13.2).

Dennis L. Kappen, Lennart E. Nacke, Kathrin M. Gerling, and Lia E. Tsotsos. 2016. Design Strategies for Gamified Physical Activity Applications for Older Adults. In *Proceedings of the Annual Hawaii International Conference on System Sciences-49*, IEEE, 1309–18. <https://doi.org/10.1109/HICSS.2016.166>

This chapter explains the results from preliminary collaborative studies which has resulted in a recent publication (Kappen et al., 2016). I used the combination of KEG (Kappen & Nacke, 2013) and SDT (R. M. Ryan & Deci, 2000a) framework to analyze the rich interview data from in informal semi-structured interview and focus group study. From Self-Determination Theory (SDT), intrinsic motivation refers to the completion of a task because it is inherently interesting or enjoyable, and extrinsic motivation refers to accomplishment inspired by the possibility of a separable outcome (R. M. Ryan & Deci, 2000a). For a continually active group involved in physical activity, intrinsic motivation was greater than extrinsic motivation (Buckworth et al., 2007). Studies involving younger populations participating in Tae Kwan Do and Aerobics revealed that exercise adherence improved when there was a greater emphasis on enjoyment, competence, and social interaction, as opposed to motives focused on fitness or appearance (R. M. Ryan et al., 1997).

5.1 Grant Collaboration

This study was carried out in close collaboration with a personal trainer, fitness instructor, and owner of Vintage Fitness, a company catering to the fitness training needs of adults over the age of 50. As a clarification, I would like to indicate that the KEG design model was created in 2013 (Kappen & Nacke, 2013) (Section 3.5) which forms one of the major contributions of this dissertation. The collaborative NSERC grant with Vintage Fitness¹² in 2014 provided the

¹² www.vintagefitness.ca

opportunity to investigate the KEG model as an analytical model in conjunction with the SDT theory. The KEG was further used as a design lens for the purpose of the development of Spirit50 (Chapter 7), a gamified application specifically meant for the older adult demographic.

5.2 Analytical Framework

The KEG is a design and analysis tool (Chapter 3, Section 3.5) (Kappen & Nacke, 2013) which has an iterative layered design approach to developing gamified technology. The analysis model is an iterative method for game designers to identify motivations facilitating internalization (Deci, Eghrari, Patrick, & Leone, 1994b), designing game experiences, game elements and integrating fun, which is focused on identifying and evaluating user motivations.

Within the KEG design model (Kappen & Nacke, 2013), I proposed the Motivated Behaviour Layer (MBL), targeted at the identification and categorization of intrinsic and extrinsic fitness motivations for a specific gamification context. I also investigated the intricacies of designing a web-based gamification application to promote motivated play of older adults involved in fitness activities.

Furthermore, I identified themes from literature (Figure 17), for each dimension indicated for the MBL. These themes served as triggers to categorize the attributes identified in the qualitative interview process. Within the intrinsic motivation sector from the MBL, the competence dimension was categorized into engagement-based, performance-based, and achievement-based themes (Allender et al., 2006; Choi, 1996; Edmunds et al., 2006). Autonomy was categorized into themes of purpose, customization, and independence (Rice et al., 2011, 2013; R. M. Ryan & Deci, 2000a; Teixeira et al., 2012), relatedness into themes of relationships, sharing, and preferences of sharing (Aparicio et al., 2012; Buckworth et al., 2007; R. M. Ryan et al., 2006; Teixeira et al., 2012). The extrinsic motivation sector was further differentiated into themes of non-self-determined extrinsic motivation, self-determined extrinsic motivation (M. Dacey et al., 2008; M. L. Dacey & Newcomer, 2005), tangible rewards, and intangible (Berkovsky, Freyne, & Coombe, 2012; Blagov, Simeonova, & Bogolyubov, 2013; Choi, 1996; Zuckerman & Gal-Oz, 2014).

5.3 Research Questions and Study

This study addressed the research questions focused on PA, motivation, and technology in the interview and focus group studies. These research questions were indicated in Section 4.5.3.

5.3.1.1 Qualitative Study 1: Semi-Structured Interviews

The Centre for Elder Research (CER), located on the Sheridan College campus, Oakville, worked in close collaboration with Vintage Fitness, a personal training and fitness company, specialised in fitness training needs of adults over 50 years of age. CER personnel conducted semi-structured interviews with 19 older adults. The interview study design was a specific investigation as part of a larger initiative. These data were provided to my research group via a memorandum of understanding through the business partner for the purposes of evaluating qualitative data. I analyzed data to extract motivational themes congruent with the SDT and KEG analytical lenses. Based on the analysis, I discuss conflicting perspectives on exercise and technology and contributed design strategies to support designers and researchers intending to create meaningful and playful fitness applications for older adults. CER recruited participants from its research database and specifically targeted adults aged 50 -70 years, who used the internet for information about health and wellness. However, I eliminated the upper age limit because some individuals over 70 years old were also avid exercisers and internet users who expressed interest in the research study, and I did not want to discount their opinions because of their age. The Ethics Boards (REB) of the CER group approved this study and the dissemination of interview data to the UOIT research group. As a token of appreciation for participating in the study, the participants were entered into a draw to win one of three exercise DVDs provided by the business partner. I conducted a follow-up in the form of a focus group study of physical trainers (PT) and older adults with an active lifestyle in an informal setting.

Interview Protocol

The semi-structured interview protocol was designed for this study by the CER in consultation with Vintage Fitness. The main themes covered in the interview protocol were: the individual's current exercise habits, factors that motivate them to begin/maintain/return to an exercise program, their goal-setting behavior, strategies they use to remain accountable, life factors that impact their exercise behavior, their needs and preferences as far as exercise is concerned, and their computer/internet behavior and preferences.

5.3.1.2 Qualitative Study 2: Informal Focus Group Sessions

Informal focus group session questions were determined on the basis of findings from the first study (interviews). I recruited participants with an active lifestyle aged 50 years and older. Six participants were recruited for the focus group sessions. These participants were deliberately selected in equally sized groups of active older adults and personal trainers (PTs). I randomized and paired each fitness trainer with an older adult to form three groups. I also assigned three researchers to each group to facilitate the questions for the informal focus group sessions.

Participants were welcomed and a consent form was provided with a brief information regarding the study. The PTs and older adult participants were assigned to informal discussion areas. A researcher assigned to each pair of participants facilitated the informal focus group session using semi-structured trigger questions specific to autonomy, competence, and relatedness for intrinsic and extrinsic motivations. A SONY audio recorder was used to record the discussions.

I created a new questionnaire (Appendix 13) for the focus group discussion session with older adults. This questionnaire focused on intrinsic and extrinsic motivational triggers to engage, maintain, and sustain motivation in a fitness activity. These questions were grouped according to the SDT constructs of autonomy, competence, and relatedness under the following dimensions: amotivation, motivation (intrinsic and extrinsic), goals and accomplishments, physical tracking, accountability, and staying on track. These questions are related to the KEG design lens for designing gamified apps as explained in Chapter 3 (Section 3.5). The questions asked in the focus group sessions are documented in Appendix 13.

5.4 Data Analysis

As explained in the analytical framework (Section 5.2), within the major categories of intrinsic and extrinsic motivation established by combining the SDT and KEG, the major dimensions within these categories were established from prior literature. Therefore deductive thematic analysis was used to reduce qualitative data to themes through the process of coding and condensing codes (Fereday & Muir-Cochrane, 2006a). Motivational dimensions shown in Figure 17 were used to allocate codes from the interview data to these dimensions. Another researcher from CER reviewed these allocations. Resulting characteristics of codes were mapped (Figure

18) and represented in tables in relation to motivational categories corresponding to autonomy, competence, and relatedness, which were defined using the KEG gamification model in combination with the SDT.

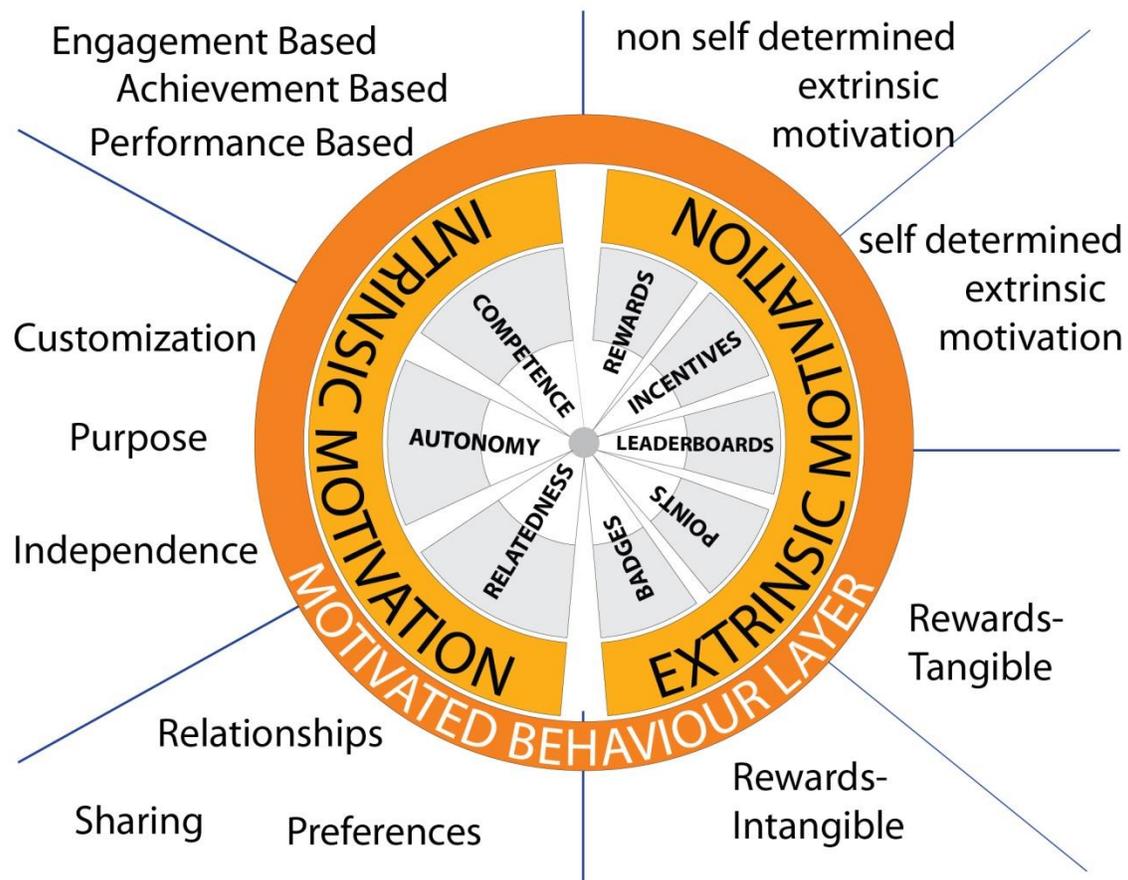


Figure 17: Categorization of intrinsic and extrinsic fitness motivations based on the KEG

5.5 Results from Preliminary Studies (Interviews and Focus Group Sessions)¹³

The interview data was recorded, and themes emerging from the review of the qualitative data were categorized based on the SDT dimensions of intrinsic and extrinsic motivations and superimposed with the KEG, specific to older adults' engagement with fitness activities and

¹³ Materials have been published in a conference paper publication and have been reproduced partially (Kappen et al., 2016)

online applications. These themes, which provided key categorizations, were: mental motivations; physical motivations; amotivations; barriers to entry (mental and physical); goal setting; accountability; rewards; support networks; social groups; sharing; social interactions; safety; preferences in physical activities; preferences with online websites; and preferences with fitness information. In order to define these themes in relation to SDT and the concept of gamification, I used the Motivated Behaviour Layer (MBL) from the *KEG* (Kappen & Nacke, 2013) as a model for comparison, mapping the attributes that emerged as shown in Figure 18.

5.5.1 Findings from Interviews

Themes coded from the review of the qualitative data were categorized based on SDT dimensions of intrinsic and extrinsic motivations specific to older adults' engagement with fitness activities and online scenarios.

5.5.1.1 Motivations – Mental, Physical and Contextual

Categorizing older adults' intrinsic motivations into existing SDT dimensions of competence, autonomy and relatedness provided distinct thematic mappings in these dimensions. Relating the competence dimension to themes as in engagement-based, performance-based and achievement-based (cf. Figure 17) provided clusters of attribute mappings within these themes.

5.5.1.2 Intrinsic Motivation - Competence

Categorizing older adults' intrinsic motivations into the existing SDT dimensions of competence, autonomy and relatedness provided distinct thematic mappings in these dimensions. Relating the *competence* dimension to engagement-based, performance-based, and achievement-based themes (see c.f. Figure 17) provided interesting clusters of attribute mapping within these themes. The complexity of activity routines, challenges with the number of repetitions, focus on remembering the activity steps, and ease of understanding the steps formed the bulk of the *engagement* theme. Participant P-1 stated “[...] I am intimidated by sports activities and was a lack of sports lifestyle during childhood, and it is easy not to work out [...].” Participant P-3 indicated “[...] I find it difficult to remember complex steps and am forgetful at times [...].” Competitive spirit, desire for maintaining healthy body condition, increasing energy levels, feeling better, improving exercise performance, losing weight, and overcoming a sedentary lifestyle related to the *performance* theme. Participant P-2 stated “[...] I have the fear of being confined to a mobility device; hence I need to keep exercising [...].” Interestingly, regarding energy levels, participant

P-6 noted “[...] I need to feel "more energy" to feel like exercising [...].” Participant P-4 indicated “[...] self-satisfaction of feeling better at end of each class, and movement is easier[...].”

Reaching smaller goals, building up on energy levels, overcoming the possibility of not being able to walk, improving range of motion and dexterity of arms and legs, and improving current body fitness levels were relevant attributes within the *achievement* theme. Regarding fitness levels, P-2 indicated “[...] stress and exercise is a challenge, however, more stressed out that I feel, the more motivated feeling about exercising [...].”

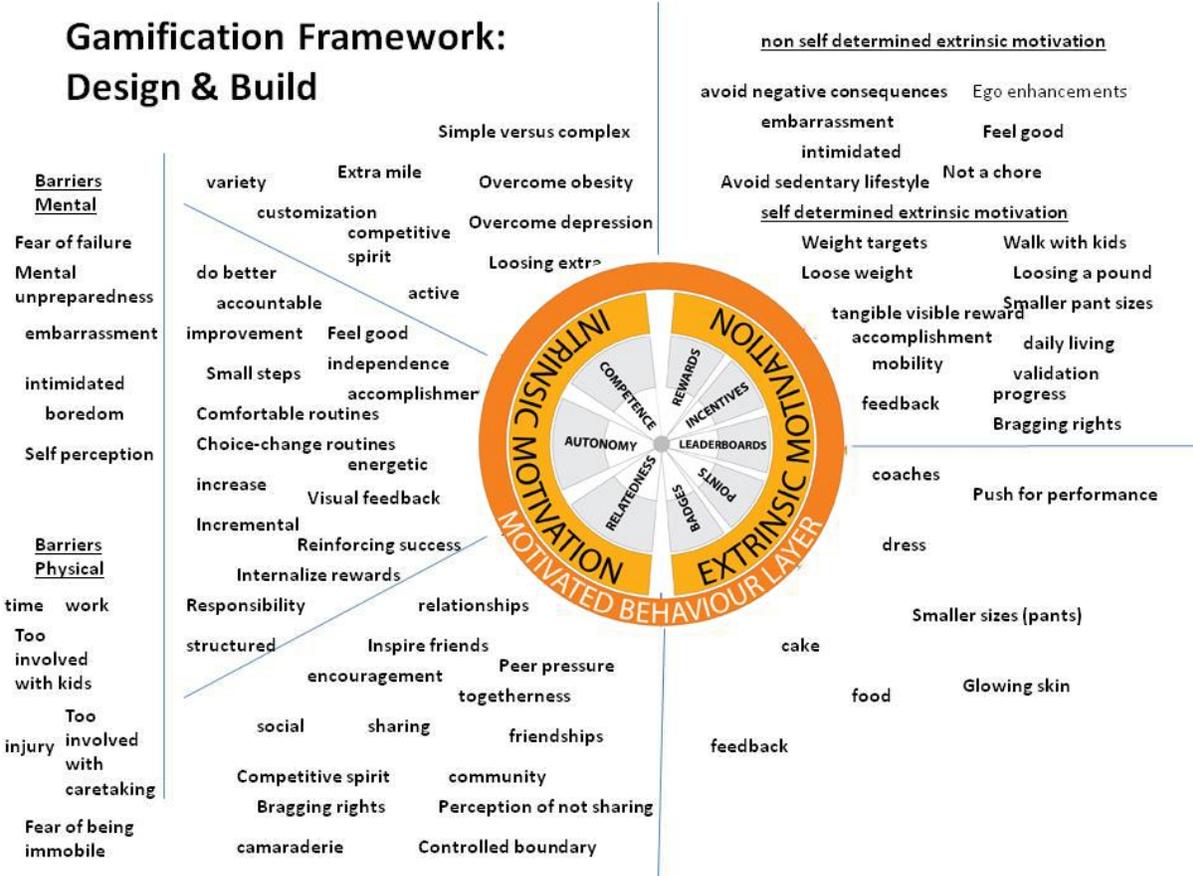


Figure 18: Characteristics Emerging from Analysis

5.5.1.3 *Intrinsic Motivations – Autonomy*

Based on the qualitative interviews, the themes of *purpose*, *customization*, and *independence* informed us about the fitness preferences of older adults within the SDT *autonomy* construct. Improved fitness performance, comfortable routines, incremental progression, reinforcing success, internalizing rewards, and responsibility formed a few of the key attributes within the *purpose* theme. Participant P-4 explained that he was keen because “[...] *the new exercise was going to provide interest, learn something new or different or new knowledge [...].*” Participant P-1 indicated that “[...] *an exercise routine was a personal challenge, as in an activity that was not done before [...].*” Participant P-4 also indicated that “[...] *I do not want to become immobile like my parents [...].*” Freedom of modulating fitness routines, structured routines, modularity, choice of changing goals, reinforcing progression through visual, and verbal feedback depicted some of the many attributes with the *customization* theme. Participant P-2 mentioned that “[...] *I prefer to break the activity into small steps, or do it in chunks or blocks of time [...].*” Furthermore, the opportunity of accomplishment at a self-directed pace, incremental selection of routines and accountability emerged within the *independence* theme. Participant P-6 mentioned “[...] *I prefer to exercise on my own and follow my own programming [...].*” and also indicated that “[...] *share goals with friends and family [...].*” to set an example [...].”

5.5.1.4 *Intrinsic Motivations – Relatedness*

I looked at the themes of *relationships*, *sharing*, and *preferences* within the SDT *relatedness* construct. Fostering social connections under the overarching context of fitness activity was a predominantly important theme for older adults. Inspiring friends and peers within and outside the activity group, engaging in competition with other people, meeting new people, providing encouragement and motivation to others, and validation from others were included in the many attributes stemming from the *relationships* theme. While participant P-6 indicated “[...] *friends and family offered encouragement [...],*” participant P-2 indicated that “[...] *a friend encouraged her and pushed her to exercise if the activities were not done [...].*” Participant P-4 mentioned that “[...] *the physical trainer offered verbal encouragement [...]*” and “[...] *I prefer trainers who push you to do work rather than passive instructors [...].*” Sharing achievements and experiences, setting an example for peers within the fitness activity domain, exchanging feedback with peers and trainers, and being validated for performance by the trainer and doctors formed a few of the attributes within the *sharing* theme. Participant P-4 indicated “[...] *I like to*

inspire and encourage friends and near ones to be active and I like to get feedback and give feedback to people [...].” In the context of *preferences*, working and being active within a group, structured social exercise activity, trainers that set attainable goals, and the comfort of being within a familiar group provided key attributes to this theme. Participant P-4 indicated “[...] *I might as well enjoy oneself and maximize the enjoyment to do the things that one wants to do [...].*” Participant P-5 indicated “[...] *I prefer to do correct repetitions as opposed to repetitions that are incorrect [...],*” and also mentioned that “[...] *likes a coach that does not "let up" [...], likes coach to "push harder " by energy levels and encouragements [...], like a "motivator" [...].*” Social interaction also formed a major attribute within the *relatedness* category. Participant P-1 indicated “[...] *I like the competitiveness with other people, working with others pushes me forward and I can gauge my own performance by the way other people are doing things [...].*” Participant P-3 mentioned “[...] *I like meeting and chatting with the ladies in the dance class, carpool and drink coffee, it tells me that I am not alone in this fitness activity [...].*”

5.5.1.5 Extrinsic Motivations

Based on the taxonomy of human motivations (R. M. Ryan & Deci, 2000a), extrinsic motivation is posited to encompass factors of external regulation, introjections (non self-determined extrinsic motivation), identification (self-determined extrinsic motivation), and integration. To expand this construct, I added tangible rewards and intangible rewards as themes within external regulation. From the thematic analysis of extrinsic motivations that emerged from the qualitative interviews, examples of tangible rewards include better looking skin, appealing dessert and indulgence in food after a fitness activity, or the prospect of fitting into a slimmer dress and giving away oversized clothes. Participant P-6 stated that “[...] *I like to eat food or desserts that I can burn the next day [...].*” Furthermore, attributes such as validation from coaches, praise, pushing for better performance, and bragging rights emerged as manifestations of intangible rewards. Participant P-3 indicated that “[...] *physical trainer's acknowledgement of my achievement itself was reward in itself [...].*” Participant P-6 mentioned “[...] *ability to exercise itself is reward for me [...].*” Interestingly, participant P-4 indicated that “[...] *it may be trite but genuine fatigue, at end of day after a fitness activity and the fact of doing all the work in the activity as opposed to eating and bored silly [...].* is the best reward [...].”

5.5.1.6 *Barriers to Entry (Fitness Activity)*

My thematic classification of engagement challenges into physical and mental barriers provided interesting insights into older adults' psyche towards fitness activities. Most participants were faced with the inertia of overcoming their lack of physical mobility due to age-related infirmities, some of which were health issues such as osteoporosis, back pain, knee issues, and bodily injuries, to mention a few. For many individuals, fatigue served to perpetuate a sedentary lifestyle, posing a further detriment towards effective fitness engagement. The most commonly noted mental barrier was a lack of confidence or positive feelings regarding fitness activity. Time constraints and a reluctance to exercise due to fear of aggravating existing health conditions was frequently cited as a contributor to inadequate exercise habits. The challenges of being intimidated by the pace at fitness workshops and the fear of being ridiculed by younger fitness enthusiasts fueled a resistance to engage in fitness activity in a social setting, such as a gym environment.

5.5.1.7 *Amotivation*

Many interesting themes emerged from this category providing insights into the lack of motivation to even initiate a fitness routine. Participant P-1 indicated that “[...] *I am a light sleeper: hence lack of sleep determines the length of time of exercise [...].*” While fear of being confined to a sedentary lifestyle posed an inclination to get involved in activities, participants struggled with the inertia of beginning a fitness routine. Participant P-2 mentioned “[...] *I am afraid of being confined to a mobility device, hence I want to get involved in an exercise routine, but I never liked sports and cannot be stressed out [...].*” Even though health was a priority for many, challenges with busy schedules or a lack of time prevented older adults from engaging in a fitness routine. Loneliness also posed a challenge; as participant P-3 mentioned, “[...] *I do not want to do any activity alone [...], and additionally; I get tired from the heat and do not like the sweaty outcome.*”

5.5.1.8 *Goal Setting and Accountability*

While these themes formed a major part of the *autonomy* category of the SDT framework and were discussed earlier; interesting attributes emerged which warranted separate analysis. Many participants preferred to set smaller and achievable goals for themselves. Participant P-5 mentioned, “[...] *small achievable goals are better than difficult ones [...].*” Sometimes, individuals preferred to allow the personal trainer (PT) to set these achievable goals for them.

Participant P-1 indicated “[...] I prefer the PT to set up the program and I trust them to understand my condition [...]” With regard to accountability, a few of the participants expected the PT to monitor their accuracy while exercising, in terms of gesture and poise. Participant P-4 mentioned, “[...] if there is improvement in flexibility and movement improves, then there is a result to the activity being done [...] hence I know that I am getting better [...].” Participant P-5 expressed a simplistic notion of accountability and mentioned that “[...] I just show up [...], which helps to maintain the fact that I am interested and keen [...].” Establishing a routine was also critical, and participant P-6 indicated “[...] I prefer to set up a regular time and day of the week for fitness activities, and, showing up for classes shows my dedication, but I prefer to do my own programming [...].” Participant P-3 affirmed that “[...] I prefer to try and exercise at least three times a week of any activity, and I maintain a diary to record my activity [...].”

5.5.2 Findings from Informal Focus Group Sessions

The interviews conducted helped to explore behavioural attributes related to the key dimensions of intrinsic motivations (i.e., autonomy, competence and relatedness, and extrinsic motivations (R. M. Ryan & Deci, 2000a)). This provided the inspiration to modulate the set of focus group questions to examine intrinsic and extrinsic motivational triggers to inspire and sustain motivation in a fitness activity.

5.5.2.1 Barriers/Amotivation

The ease of maintaining a sedentary lifestyle due to stationary work environments posed a crucial barrier for older adults to engage in fitness activity. Participant 1 from focus group 1, coded as PF2, indicated “[...] non-availability of time due to work commitments and schedules made me postpone fitness activities. I am often sitting in front of a computer busy doing something or the other [...].” PF3 said “I do not have not enough time available, but joined a gym due to back injury [...], however fear of failure and the need to be ‘fit to be fit’ was a stressor,” adding that “[...] I am ashamed or embarrassed, and mentally not ready or not keen on being seen in gym attire and furthermore I am intimidated by the buff fitness younger guys [...].” Participant PF1 said “[...] I forgot about myself while giving to the younger generation; which was a sacrifice and hence was too busy; I did not have the time or did not take the time to make the time for fitness activities.”

5.5.2.2 Motivations

During the sessions, the participants were asked about their motivation triggers to engage in a fitness activity. Regarding physical activity, PF1 said “[...] *physical activities in the past were social and revolved around food [...].*” Space constraints at home formed another trigger to join a gym. Participant PF2 said, “[...] *there was lack of opportunity for movement at home hence joined a gym to take part in a routine [...].*” Participant PF3 said “[...] *I get bored too easily and hoped that the gym activity would make it more interesting [...], additionally the gym was on the way home and close to home [...].*” PF3 also said, “[...] *engaging in fitness routines enable me to play with my granddaughter and kick a ball around [...].*” Regarding capability, participant PF2 said “[...] *I feel capable when I am able to perform the exercises correctly [...]*”; for PF1, “[...] *the understanding that the small steps from the trainer would help to overcome the barriers of being overwhelmed with the idea of being able to do the activity [...]*”; for PF3, “[...] *seeing a weight loss in the mirror is a driver, small goals, small steps to be successful and then take it higher [...].*”

Participant personal trainer from group 1, coded as PPT1, said “[...] *most of my clients are keen on trying to do a simple routine and be successful at it [...], and they like being praised [...].*” Interestingly, it was noted that excessive feelings of negativity or unfavorable connotations could suppress positive outcomes and that reinforcing small successes increased motivation. Regarding competency, participant PF1 said “[...] *when I can do the exercises that I remember, and to do these simple ones makes you feel better for that moment [...], and extend my feeling on my own to other activities. Including comfortable routines independently into daily activities as when taking a shower, gives the feeling of independence [...].*” PF2 said, “[...] *if I am able to do better and increase my workout from being better than my planned approach [...].*” PF3 indicated “[...] *I have been quite active in the past and hence competence comes from small goals [...].*”

When asked about the value of rewards in overcoming mental and physical barriers, participant PF1 said “[...] *Not quite [...]. If I promised myself a reward [...], it still would not help. The external reward would be losing that extra weight or being able to walk that extra mile, I would challenge myself to do more [...], success motivates me, the reward was the progress. I wanted to inspire other friends to be active as I am, to overcome obesity and depression [...].*” Participant

PF2 said “[...] *the reward is purely from being able to feel better and feel good. Also, the benefit is from being able to feel energetic and wear smaller pant sizes [...], the thought of competition is also a different feeling as I was always of a competitive spirit [...].*” PF3 indicated “[...] *reward is your health which seems to be a more important aspect in older age [...].*”

Additionally, personal trainer PPT3 said “[...] *most of my clients were not keen on medals or certificates, but were keen on praise which helped to validate their progress [...].*” PPT2 also said “[...] *my clients were more interested in me recognizing their individual successes because one client mentioned to her that this acknowledgement made them feel as though she existed for the PT on her radar [...].*”

5.5.2.3 Accountability and Staying on Track

The degree of accountability varied for different participants. Participant PF1 said “[...] *I prefer to be accountable to oneself, and to the PT, to be accountable online may be difficult as it needs to be a personal connection [...] as opposed to being a non-relationship avatar [...].*” Participant PF2 said “[...] *yes, it feels good to measure one’s progress [...].*” Participant PF3 said, “*I commit to doing an activity and maintain this in my diary [...].*” Concerning personal accountability for fitness goals, participant PF1 said “[...] *I do this by counting the calories and making effective choices as in good choices or bad choices, (good guys, bad guys) [...]. I seem to play mental games about this with myself.*” With respect to the role of accountability in sustaining motivation, participant PF1 said: “[...] *accountability to yourself help to maintain motivation, gives the feeling of more energy when you consume lighter foods, rather than letting oneself down.*” Participant PF3 said, “*you don’t want to drop out for fear of not being able to keep up [...].*” From the perspective of being rewarded to stay accountable, participant PF1 said: “*I do not think so [...] reward is feeling good about yourself, fitting in clothes.*” PF2 said “[...] *no, the reward is the hitting the targets and maintaining the body fitness level and mental health [...].*” PF3 echoed this and said, “*not quite, the feeling of doing well helps [...].*” Regarding accountability to someone else, PF1 said “*preplanning, and the need to keep up with the goals set by the PT or a group or to another team person make the process encouraging [...].*” PF2 said, “*accountability to oneself is better than others; however, accountability to a teacher or PT helps with validation.*” PF3 said, “[...] *the presence of a PT helps with being on track.*” PF1 remarked that in regards to staying on track, “[...] *knowing how many kilometers one walked was*

fascinating to know this information. This info was also motivating. Like walking/shopping but more valuable [...], a feedback of progression via a computer [...] would be stressful [...], but not keen on a computerized feedback [...], as I am not of digital age.” PF2 said, “[...] sometimes working with equipment helps with getting feedback instantaneously [...].” Physical trainer PPT3 said, “[...] my clients are always keen on knowing from me if they hit their target that was planned of the activity.”

5.5.2.4 Social Context

Social interaction and sharing during fitness activities between older adults was noted as a means of respecting and understanding the presence of many in situations similar to their own. PF1 said *“[...] Being with a group or another person motivates me, DVD given by the PT as an exercise motivates the person to do the exercise, as opposed to finding a DVD and doing it ourselves, recommendation of fitness activities help [...].”* PF2 said, *“[...] being together and recognizing that there are others in the same boat as you [...].”* PF1 said *“[...] I like help from other people, and bounce off ideas with others but prefer a professional opinion [...].”* PF2 indicated *“[...] I do not mind sharing information about my success or failures, as the opinions of others affect my persona only in a small manner [...].”* PF3 said, *“I like to build friendships and a common element ties people together in a fitness activity especially at in older age group [...].”*

5.5.3 Preliminary Studies - Discussion

Analysis of interviews and focus groups revealed a range of motivations for older adults that could inhibit or facilitate exercise. I discuss these findings and relate them back to SDT and KEG aspects that would help augment PA for older adults with technology. Motivating factors are:

Intrinsic motivations can be broken down into purpose of the exercise, customization of exercise routines, independence of how and when to work out, the ability to form relationships, and being able to share information about exercise. Togetherness and sociability at a common location was emphasized in the focus groups. Older adults use PA in a gym setting to connect with others of their own age (keeping in mind that the presence of younger, active persons may act as an inhibitor and reduce confidence). This emphasised the importance of social interaction that could be incorporated in technology. In addition, the fear of incompetence and immobility is a strong intrinsic motivator for older adults: interview sessions and focus groups show that the

importance of exercise to maintain an attractive body is shifting to the application of exercise to reverse or avoid age-related changes and impairments and to maintain a *functional* body (e.g., being able to play with grandchild, or not having to use assistive device in the future). Fear of aging can drive a desire to exercise in some cases because responses were rather emotional and explicitly focused on physical impairments they had witnessed in other people.

Small goals and simple routines are important design factors mentioned in the focus group session. Older adults expressed strong preferences for simplistic exercises that are easy to learn and allow them to take ownership by designing experiences that fit their lifestyles and abilities.

Extrinsic motivations are not as valued by older adults and tangible rewards are mostly related to food, while intangible rewards often relate to acknowledgments and praise from their PTs. Good food choices can also be motivating when they fit into the exercise regimen.

Barriers to exercise can be physical and mental, which are often related to an age-related health condition or injury, and also appeared to have an impact of older adults' self-image, e.g., causing insecurities when comparing themselves to younger persons. In this context, it is interesting that interview questions designed to investigate how older adults experienced competence in the context of PA largely evoked answers focused on their *incompetence*, fear of failure, and perceived barriers, suggesting a self-conscious perspective on PA. Other factors were mental barriers such as the embarrassment of working out in public, and technology was often mentioned as a potential barrier.

Praise, wellbeing and health benefits are seen as natural rewards in exercise regimens for older adults. A recurring theme that was observed was the importance of feedback. Older adults expressed strong needs for continuous feedback on their performance (e.g., whether movements were carried out correctly, and whether they were making progress) either from the fitness instructor or from peers. This was supported by PTs who participated in the focus groups, who also outlined that continuous positive feedback might help increase older adults' confidence when engaging in PA. Despite their strong need for external approval, older adults expressed

concerns when asked whether they would like to receive performance feedback through a computer system, highlighting a challenge when creating PA applications for them.

The above thematic analysis using SDT and KEG as an analytical lens helped to identify key motivating factors, which were internalized by the older adults engaged in PA. This helped to answer the secondary research question (SRQ1). This exploratory process of using SDT and KEG in conjunction helped to identify key barriers and factors discussed above which were of prime importance in the design strategy of a fitness gamification application and supported the secondary research question (SRQ2).

Applying SDT and KEG to Study Fitness Motivations

The combination of SDT and KEG helped to identify and analyse fitness motivations for older adults. This understanding helped to identify motivations from the MBL layer of the KEG, an important first step for designers to design fitness applications with attributes of personal importance to the older adult demographic. This method helped to identify needs and wants of older adults geared to satisfy the need satisfaction dimensions of autonomy, competence and relatedness. Thus, an intersection of SDT—a psychological model used in KEG—facilitated the discovery of needs of the specific demographic. This further helped with the development of strategies for designing playful technologies for PA motivation among older adults. I used these strategies and the needs and wants of older adults to develop the EMTF (Section 5.6) and the Spirit50, a gamified PA technology for older adults (Chapter 7).

Strategies for Designing Playful Technologies to Support PA among Older Adults

The findings exposed a number of design challenges that need to be addressed when creating interactive systems to support PA among older adults. This section lists four key challenges (SRQ3) that were condensed from the analysis.

Challenge 1: Understanding the life stage of older adults to motivate users without playing on their fear.

Design strategy: Highlight benefits of PA without referencing age-related changes.

Challenge 2: Offering engaging feedback on PA routines.

Design Strategy: Provide feedback while offering older adults some of the benefits of technology-supported PA; designers should explore opportunities to use automated feedback.

Challenge 3: Enabling social sharing to create community while avoiding social pressure.

Design strategy: Mindful (Mercer et al., 2015) sharing. Be clear about what is shared. Pick the right things to share as in encouraging messages, peer support messages, anecdotal messages.

Challenge 4: Supporting PA, encouraging ownership, and enabling autonomy.

Design strategy: To engage older adults, designers need to define experiences that enable older adults to take ownership of PA.

A detailed discussion of this section can be seen in the design strategies publication (Kappen et al., 2016).

5.6 Exercise Motivation Technology Framework

Thematic analysis of the qualitative data from semi-structured interviews and focus groups lead to the development of the goal based Exercise Motivation Technology Framework (EMTF) for older adults and their participation in PA.

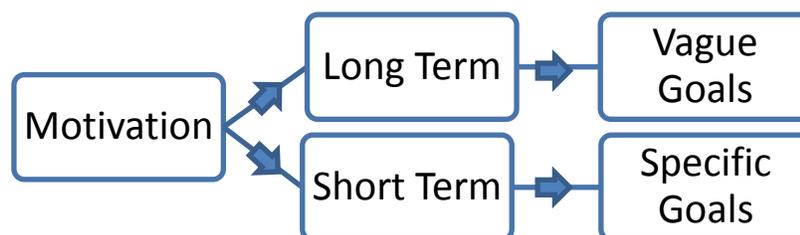


Figure 19: Categorization of Exercise Motivations (EMTF-1)

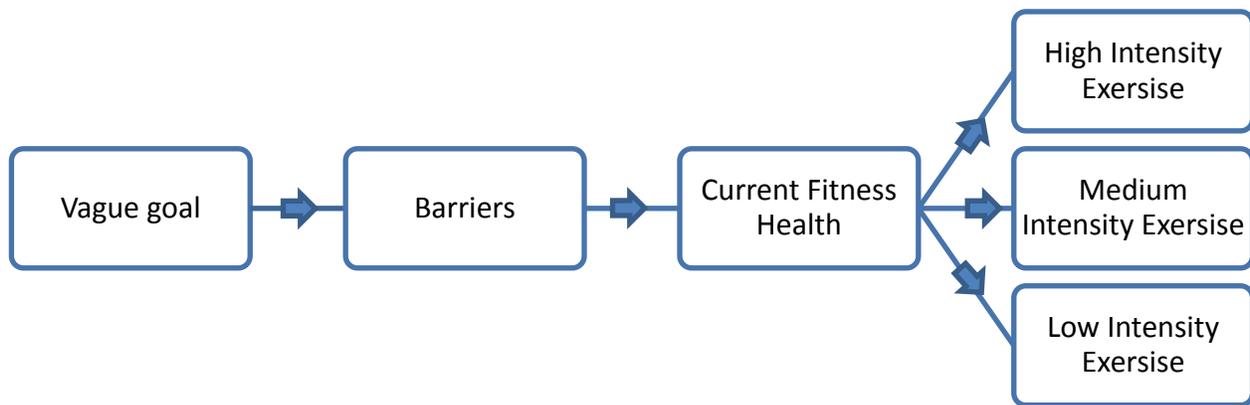


Figure 20: Dependencies of Vague Goals to Exercise Intensity Workflow (EMTF-2)

From the thematic analysis of qualitative data, the overall motivations of older adults for participation in PA were categorized into long-term goals and short-term goals. Long-term goals were termed as *vague goals*; short-term goals were indicative of *specific goals* as immediate motivational aspirations.

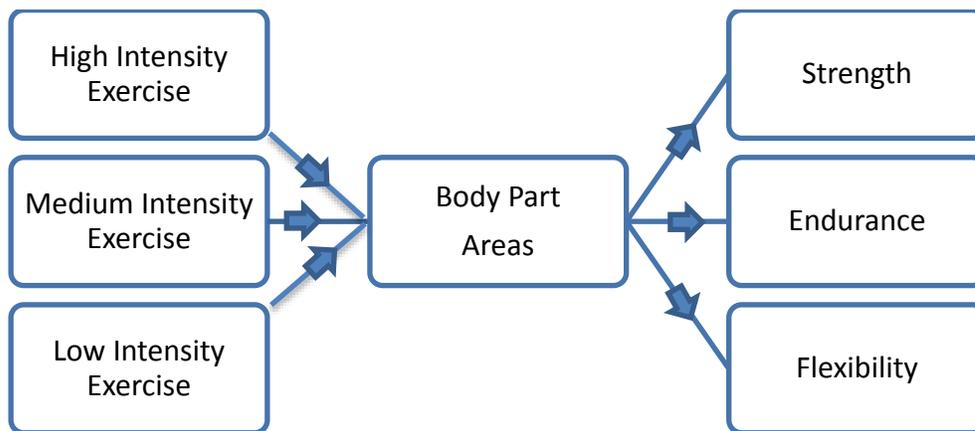


Figure 21: Current Fitness Health - Body Part Areas and Exercise categories (EMTF-3)

Additionally, I identified clusters of specific goals that corresponded to each vague goal. There existed a one-to-many relationship between each vague goal and multiple specific goals, as shown in the tabular matrix in Appendix 13.2.

Furthermore, each specific goal was assigned a *barrier* (an obstacle to engaging in PA) as deduced from preliminary studies (Kappen et al., 2016). Each barrier was then related to specific *current fitness levels* pertaining to particular Body Part Areas (BPA).

Each BPA had questions pertinent to challenges faced within that BPA, which was processed to output an exercise fitness intensity level (Figure 21) appropriate for the user. The fitness intensity levels were calculated by an algorithm based on the values input by the user for the BPA questions.

The categorizations of the older adults' exercise motivations (Figure 19), the dependencies of vague goals to exercise intensity (Figure 20) and the relation between BPA, exercise intensities and exercise type (Figure 21) formed the *EMTF*.

5.7 Limitations and Future Work¹⁴

As this work is of exploratory nature, there were some limitations related to the sample of older adults that was included. First, many of the older adults that were interviewed were already physically active and not completely sedentary. They were interested in working out more regularly, which might lead to some bias toward PA in this study, and it is important to view the findings in this light. More work is necessary to survey attitudes towards technology-supported physical activity among older adults leading sedentary lifestyles, and results might imply the necessity of different technology solutions. Another opportunity for future work lies in the comparison of perspectives on technology-supported PA among older and younger adults. It would be helpful to explore how an older and younger demographic differ in exercise motivations, how both groups approach currently available technologies to support PA, and how they view gamification of activity.

¹⁴ Materials have been used for the conference paper publication and have been reproduced partially (Kappen et al., 2016)

5.8 Summary¹⁵

PA is important at all life stages. While health tracking and gamification of physical exercise are on the brink of becoming part of the daily routines of the younger population, little technology is available to support the efforts of older adults wishing to maintain PA routines. This work provides first insights into older adults' perceptions of technologies to support PA with the goal of helping researchers and designers better understand design challenges when creating playful applications for this demographic. Creating tangible and real digital applications affording the upkeep of motivations, monitoring progress, providing validation and support; and social connections will help to reinforce the necessity of technological interventions for the betterment of older adults PA. In the context of older adults' lives, such technologies would enable them to support their efforts to stay healthy, and help them maintain and establish PA routines which are crucial to well-being in late life.

¹⁵ Materials have been used for the conference paper publication and have been reproduced partially (Kappen et al., 2016)

Chapter 6

6 Phase 2: Survey Study

Based on findings from Chapter 5, an investigation into motivational preferences of adults in different age groups was necessary to understand the possibilities for customizing and tailoring motivational affordances for PA technology. Materials from this chapter have been published in a peer-reviewed conference proceeding since the submission of this dissertation.

Dennis L Kappen, Pejman Mirza-Babaei, and Lennart E. Nacke. 2017. Gamification through the Application of Motivational Affordances for Physical Activity Technology. In *Proceedings of CHIPLAY '17*.

6.1 Survey Study on Motivational Affordances for PA Technology

Commercial fitness games, such as Nintendo's Wii Fit games or Majesco's Zumba Fitness games are designed with the general population in mind and not tailored individually to specific age groups. While monitoring of fitness using technologies like Fitbit ("FitBit," 2015), Nike+ FuelBand ("Nike+ FuelBand," 2014), and Google Fit ("Google Fit," 2015) have motivated maintain and track PA, it is not clear how people in different age groups use these technologies specifically. The motivation of younger adults (Rice et al., 2013) and older adults (Motalebi et al., 2014) to keep fit are different. With a growing aging demographic, older adults are trying to lead healthy lifestyles while maintaining physical and mental wellness (Barwais et al., 2013; Buffart, Westendorp, Van Den Berg-Emons, Stam, & Roebroek, 2009). Compared to the younger population, not all older adults engage with fitness in the same way, and they often face more substantial cognitive and physical (Schutzer & Graves, 2004b). Therefore, it is important to compare the motivations and preferences of adults in different age groups.

Motivational affordances (Juho Hamari et al., 2014; Lister et al., 2014) for PA facilitation are elements which help facilitate intrinsic or extrinsic motives to participate in PA. This idea follows from gamification, which is applying strategies from game design (e.g., actions, challenges, and achievements) to daily activities to make people's actions more engaging

(Deterding, Dixon, et al., 2011). Research shows that gamified fitness applications are health interventions that have the potential to engage people in regular PA (Lister et al., 2014). The motivations of adults in different age groups to become physically more active (i.e., PA motivation) have not been studied in detail. Their preferences for motivational elements facilitating their participation in PA (i.e., PA facilitation) have also not been explored before. Therefore, this survey was conducted by combining open-ended questions and self-report scales such as the Exercise Motivations Inventory (EMI-2) (Markland & Ingledew, 1997), to compare the PA motivations of adults in different age groups (i.e., 18-29, 30-49, 50-64, and >65 years old) and to investigate their preferences for motivational elements that facilitate PA.

Findings from this survey study with 150 participants indicate a significant difference in motives to participate in PA in the health pressures and ill-health avoidance EMI-2 dimensions between the four age groups compared. Additionally, the findings indicate differences in what motivational affordances are preferred by the four different age groups, leading to age-group-specific design guidelines.

This study makes four contributions to this thesis progression: (1) the study provides empirical evidence of significant differences in motives for becoming physically active between four age groups. (2) The results suggest preferences in motivational affordances between four age groups, which lead us to suggest different motivational affordances tailored for different age groups. (3) The content analysis segregates motivational elements into gamified motivational affordances and feedback elements. (4) Finally, we provide age-specific design guidelines for incorporating motivational elements into the technology used for facilitating PA. A better understanding of how interactive technologies can meet the needs of adults in different age groups enables us to create a meaningful fitness and PA technology.

6.2 Theoretical Development

SDT posits that self-regulation of uninteresting activities is an inherently motivational construct which occurs through the process of internalization (Deci et al., 1994a; Gardner & Lally, 2013). Facilitating internalization (Deci et al., 1994a) also serves as a strong catalyst to engaging with a

gamified application. However, the expectation of extrinsic rewards can marginalize intrinsic motivation (Deci et al., 1999; R. M. Ryan & Deci, 2000b). Intrinsic motivation is facilitated when autonomy, competence and relatedness, the three psychological needs of human motivation are satisfied (R. M. Ryan et al., 2006). From an SDT and PA intersection, integrated regulation was an important predictor of exercise behaviour (Duncan, Hall, Wilson, & Jenny, 2010). For PA technology—while using extrinsic motivational affordances like virtual rewards for PA were inconclusive—for middle-aged adults (mean age = 31.8 years), social comparison provided greater motives to participate in PA (Zuckerman & Gal-Oz, 2014).

To select a scale for this study, different measures used by researchers to study motivation and PA were reviewed. The Intrinsic Motivations Inventory (IMI) (McAuley et al., 1989) discussed the need for accurate assessment of psychological constructs in a competitive sports setting, finding that apparent intrinsic motivation may be extrinsic, fuelled by rewards such as weight loss, improvements in physical appearance, and social recognition (Markland & Ingledew, 1997). The Self-Motivation Inventory (Dishman & Ickes, 1981) aimed to identify variations in adherence to physical activity and dropouts (Goldberg, 1983) among female and male participants. The Exercise Motivations Inventory (EMI) (Markland, 1999) and Exercise Motivations Inventory-2 (EMI-2) (Markland & Ingledew, 1997) posited a collection of exercise participation motives in adults applicable to both exercisers and non-exercisers. The Psychological Need Satisfaction in Exercise scale (PNSE) indicated high levels of *need satisfaction* in exercise contexts (Wilson et al., 2006). Since the focus of this study was to

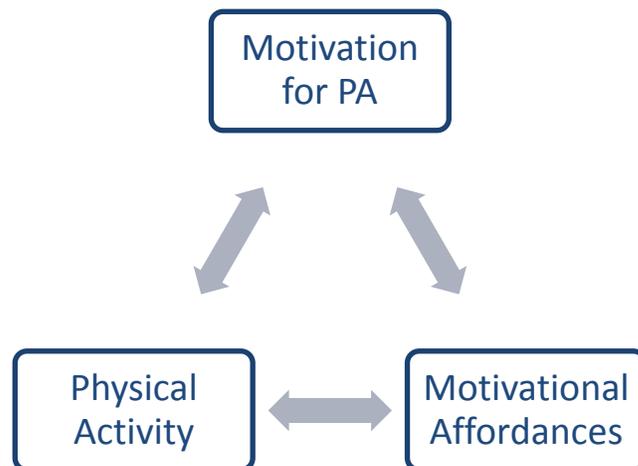


Figure 22: Triangulation of Motivation-PA-Motivational Affordances

compare motives to participate in PA between age groups, it was decided to use the EMI-2, a 51 item, 14 dimensions self-report scale (1= not all true for me, 7= very true) for this survey study. Given the focus of investigating motives and preferences for PA with towards motivational affordances, the theoretical development in this study consists of the triangulation (Figure 22) of the following three domains: 1) Motivation for PA, 2) Motivational Affordances and 3) PA.

6.2.1 Research Questions for Phase 2

Participation in daily PA, exercise or fitness routines is critical to overcoming a sedentary lifestyle and helps to maintain and improve health and wellbeing in adults of all ages (Bamidis et al., 2014; Far et al., 2015; Gardner et al., 2014; Moore, Moore, & Murphy, 2011). Motivation to participate in PA can be afforded through gamified behaviour change strategies (Berkovsky, Coombe, Freyne, Bhandari, & Baghaei, 2010; Kappen et al., 2016; Payne et al., 2015). However, little research has been done to compare the differences in preferences of motivational affordances in PA between age groups. Usage of devices and apps to help monitor physical activities and exercise routines provides monitoring of progression or decrements over time (Lister et al., 2014). Many of these apps situate motivational affordances to help foster intrinsic and/or extrinsic PA motivation (Shin & Jarrahi, 2014). Additionally, the understanding of age group specific preferences of these motivational affordances is critical for integrating these into the design of PA technologies in mobile PA applications or wearable technology devices that facilitate participation in PA. While a non-tailored, generalized approach is being used in the current design of fitness tracking and gamified PA technology, more research is needed in understanding the preferences of adults of these motivational affordances in different age groups. Thus, research questions for this study were as follows:

RQ1_{Ph2}: Are there differences in motivation to participate in PA between adults from different age groups?

RQ2_{Ph2}: Does the choice of motivational affordances change with age between the groups?

6.3 Study Design and Method

This survey study was conducted using a questionnaire in an online and a printed format. A recruitment drive for participants was carried out through email, blog posts, and by posting the

survey link through social media channels such as Twitter, LinkedIn, Facebook, and through recruitment at community and fitness centers. Survey studies have contributed to the human-computer interaction community through the investigation of personality-targeted gamification (Jia, Xu, Karanam, & Voids, 2016), social influence on gamification (Juho Hamari & Koivisto, 2015b) and persona development (McGinn & Kotamraju, 2008), to mention a few. I referenced recent CHI papers on survey studies for methods and procedure for reporting survey results (Bopp, Mekler, & Opwis, 2016; Jia et al., 2016).

6.3.1 Survey Design

A “by hand” option was also included because older adults (65+) were also target participants for this study. This questionnaire was a compilation of the EMI-2 (Markland & Ingledew, 1997) - a revised Exercise Motivations scale, demographic questionnaires and questions on preferences of motivational affordances to participate in PA. The EMI-2 is a multidimensional, 51-item scale, designed to assess an individual’s exercise participation motives. These 51 items are categorized into 14 dimensions (Stress Management, Revitalization, Enjoyment, Challenge, Social Recognition, Affiliation, Competition, Health Pressures, Ill-Health Avoidance, Positive Health, Weight Management, Appearance, Strength & Endurance, and Nimbleness). This survey was modified by replacing the term “exercise” with “physical activity”. This was done to include wide range activities defined as light, moderate or strenuous PA, which is relevant for older adults (Cheung, 2015).

6.3.2 Participants

Data were collected over a four-month period (April 2016- July 2016). Participants were offered the chance to enter to win one of three Amazon.ca gift cards each valued at \$30 CDN. In total, 192 participants took part in the survey: 22 respondents filled the survey by hand which was then transferred to the survey database, 170 responses were completed in an online questionnaire format. 42 of the total survey responses were deleted because of incomplete data. This resulted in a final number of 150 responses.

6.4 Results

The results of the survey are reported in the following sections.

6.4.1 Participant Demographic

Most PA guidelines are defined for age groups: adults (18-64) and older adults (65+) groups (CSEP, 2012; World Health Organization, 2010). However, to compare the needs and preferences of adults in different age groups, the age cohorts from a study on adults and gaming was used (Jones & Fox, 2009). This is because the survey study focused on investigating the motivational affordances for technology adaptation among adults. For this reason, the PEW Research age cohorts was used (Jones & Fox, 2009), which was the closest published research comparing age groups and gaming technology. Based on PEW guide, data were categorized into the following age groups: 18-29 (G1), 30-49 (G2), 50-64 (G3), and 65+ (G4). These groups were coded as 1-4 for data analysis. Gender was equally distributed (Female=75, Male=75) in the total sample population and the gender diversity within each group is shown in Table 8. More detailed characteristics of participants are shown in Appendix 13.4.2.

	Total Participants (N=150)	
Age	(1) 18-29 (17, 11.3%) (GF=11, GM=6)	M=25.7, SD=2.5
	(2) 30-49 (58, 38.7%) (GF=28, GM=30)	M=39, SD=5.85
	(3) 50-64 (43, 28.7%) (GF=25, GM=18)	M=56.9, SD=3.9
	(4) 65+ (32, 21.3%) (GF=11, GM=21)	M=71.9, SD=4.9
Devices used to play digital games	Smartphones	35.0%
	Cell-Phones	11.7%
	Tablets	22.3%
	Desktop PC	9.7%
	Laptop computers	9.7%
	Game Consoles	7.8%
	Online	1.9%
	All on the list	1.9%

Table 8: Participant Demographic

Demographic information was collected from participants (as a percentage of the overall sample population) relating their age, gender, hours spent sitting in a day, hours spent sleeping in a day, inclination to play digital games, devices used to play games, time spent in physical activity per day, apps used to monitor physical activities and devices used to monitor physical activities.

Detailed information of this demographic profile that is not shown in Table 8 is shown in the appendix (Section 13.4.2).

6.4.2 Data Analysis

A mixed-method approach was used to analyzing the data. Survey responses from the EMI-2 questionnaire were analyzed quantitatively. Content analysis was carried out on the long-form text responses and analyzed for frequency of occurrences.

6.4.2.1 Reliability and Normality

All 14 dimensions of the EMI-2 scale (Markland & Ingledew, 1997) had high reliabilities, Cronbach's $\alpha = .90$. The scale reliability with dimensions deleted is shown in supplementary materials. Data from the 51-item, 14-dimension EMI-2 scale was non-normal (Kolmogorov-Smirnov test).

6.4.2.2 Motivational Differences between Age Groups

Non-normal data from the four groups categorized by age were tested using the Kruskal-Wallis test for differences (Table 9, Table 10). Only two dimensions, health pressures, $H(3) = 7.96$, $p < .05$, and ill health avoidance, $H(3) = 8.90$, $p < .05$, differed significantly between age groups. This indicated that between the age groups', health pressures and ill health avoidance motivated individuals to participate in PA.

Kruskal-Wallis Test

Ranks			
	age in categories_newrange	N	Mean Rank
Health Pressures	18-29	17	52.94
	30-49	58	71.69
	50-64	43	81.22
	65+	32	86.70
	Total	150	
Ill Health Avoidance	18-29	17	46.47
	30-49	58	77.60
	50-64	43	79.85
	65+	32	81.27
	Total	150	

Table 9: Kruskal-Wallis Test

Test Statistics ^{a,b}		
	Health Pressures	Ill Health Avoidance
Chi-Square	7.957	8.908
df	3	3
Asymp. Sig.	.047	.031
a. Kruskal Wallis Test		
b. Grouping Variable: age in categories_newrange		

Table 10: Kruskal-Wallis Test - significance values

Since the above test gave only the overall statistic, pairwise comparisons using the Mann-Whitney test were done to follow up on the findings and investigate further differences between age groups within the two dimensions indicated above. Since the focus of the dissertation was on older adults, G1 (18-29) was used as the control group and compared with the other three age groups. Health pressures (HP) and ill health avoidance (IHA) and dependent variables (DV) were significant with age-group 2 (30 - 49), age-group 3 (50 - 64) and age-group 4 (65+) as shown in Table 11, with all effects reported at $p < .05$.

DV (control)	Age Category	Statistic
HP	30-49	$U=358, r = -.20$
	50-64	$U=224, r = -.30$
	65+	$U=165, r = -.32$
IHA	30-49	$U=284, r = -.30$
	50-64	$U=206, r = -.34$
	65+	$U=146, r = -.38$

Table 11: Mann-Whitney U Statistic. EMI-2 scale dimensions: HP = Health Pressures; IHA = Ill Health Avoidance.

Furthermore, Mann-Whitney tests were carried out between the groups 2 and 3, 2 and 4, and 3 and 4, however no significant differences between groups was indicated.

Additionally, in order to investigate the trends in dimensions between age groups the Jonckheere-Terpstra statistic was selected to test for ordered patterns of the averages of the 14 EMI dimensions of the four age groups being compared. Jonckheere's test revealed a significant trend in the health pressures ($J = 4795, z = 2.78, r = .22$), ill health avoidance ($J = 4579, z = 2.02, r = .16$), and nimbleness ($J = 4716, z = 2.495, r = .20$), with all effects reported at $p < .05$.

6.4.2.3 Motivational Affordances for PA

Survey questionnaire respondents answered the following five questions:

1. What *types of feedback* do you look for in an app to help you with PA?
2. Can you suggest attributes in the app that could *motivate* you to participate in PA?
3. Can you suggest attributes in the app that *do not motivate (negative attributes)* you to participate in PA?
4. Can you suggest attributes in the app which could *help facilitate goals* for PA?
5. Can you suggest any attributes which could help you *continue to participate in physical activity* sessions over a longer period of time?

Content analysis of the answers to long form text questions in the survey was done using Excel.

Long-form text data were categorized based on the motivational affordances for PA (Juho Hamari et al., 2014; Lister et al., 2014) which are shown in Table 12.

Motivational affordances	Reference
Points	(Juho Hamari et al., 2014; Lister et al., 2014)
Leaderboards	(Juho Hamari et al., 2014; Lister et al., 2014)
Achievements/Badges	(Juho Hamari et al., 2014)
Levels (of achievement or rank)	(Juho Hamari et al., 2014; Lister et al., 2014)
Story/Theme	(Juho Hamari et al., 2014)
Clear goals	(Juho Hamari et al., 2014)
Feedback	(Juho Hamari et al., 2014; Lister et al., 2014)
Rewards	(Juho Hamari et al., 2014; Lister et al., 2014)
Digital rewards	(Lister et al., 2014)
Real world prizes	(Lister et al., 2014)
Progress	(Juho Hamari et al., 2014)
Challenge/ competitions	(Juho Hamari et al., 2014; Lister et al., 2014)
Social or peer pressure	(Lister et al., 2014)

Table 12: Motivational Affordances

The frequency of occurrences of the attributes was determined as a percentage of the total number of attributes (n_{att}) listed by the respondents per age-group. While content analysis revealed many attributes for each question, excerpts of percentages of the attributes for each of the question categories are reported. Detailed frequencies are provided in the Appendix (Section 13.4.4).

Types of feedback: A comparison of the *types of feedback* provided by each group revealed that respondents wanted different types of feedback. Excerpts of the percentages of feedback attributes are reported for each group in Table 13. Frequencies and affordances with lower percentages are seen in the Appendix (Table 62).

A few responses from G1 were: for **calories:** *'I would look for calories'; 'calories burnt'; 'calorie counter'*; for **heart rate:** *'[...]it would be good to see heart rate'*; for **step-counters:** *'noting steps is like hitting a mark'*.

Select responses from G2 were: for **calories:** *'[...]used for calorie count/ calories burned'*; for distance travelled and step counters: *'step counter to see the distance between places and sometimes how many calories needed to be burn(ed) if I eat a certain type of food'; 'the number of calorie / weight / progression / number of steps'*.

Interesting responses on feedback from G3 were: for **time:** *'want to do this often'; 'the more I do it, the faster I go; 'check time taken to do this'; 'performance improvement over time'*; for **points:** *'like to see my points'*; for **feedback:** *'step counters and calorie counters'; '[...]with Fitbit: Step and miles counter'; 'immediate feedback on number of steps taken'*.

Age Cat	Types of Feedback
18-29 (n _{att} =51)	Calories (15.7%), Heart rate (13.7%) step counters (9.8%)
30-49 (n _{att} =110)	Calories (18.2%), distance travelled (15.5%), step counters (16.4%)
50-64 (n _{att} =88)	Time (19.3%), points (17%), feedback (11.4%)
65+ (n _{att} =117)	Step-counters (17.9%), distance travelled (14.5%), calories (14.5%)

Table 13: Types of Feedback

Responses from G4 were: for **step-counters** and **distance travelled:** *'feedback on steps'; 'steps, I walk a lot'; 'If an iPhone app could detect walking'; and calories: 'calories monitoring device'; 'calories burnt'*.

Motivation to participate in PA: Excerpts of preferences of attributes that could motivate one to participate in PA between each of the four age groups is shown in Table 14. Frequencies and affordances with lower percentages are seen in the Appendix (Table 63).

Age Cat	Affordances
18-29 (n _{att} =44)	Badges (11.4%), progression (11.4%), goals (9.1%)
30-49* (n _{att} =96)	Calories (10.4%), progression (8.3%), step-counters (7.3%),
50-64** (n _{att} =57)	Calories (12.3%), distance travelled (12.3%), weight loss (8.8%)
65+ (n _{att} =94)	Step-counters (10.6%), distance travelled (10.6%), progression (10.6%)

Table 14: Affordances to help participate in PA

Select responses regarding affordances that helped participation in PA from G1 were: for **badges**: *'[...]I like receiving badges'; '[...]anonymous competition between friends resulting in things like Fitbit badges'*; for **progression**: *'[...]seeing how far behind I am compared to friends'; 'progress indicator towards goals'; 'comparison of past few results towards a goal'*.

Notable responses from G2 were: *'[...]need to know calories and general trend'; calories burned'*; for **progression**: *'the Nike running app has motivated me to run more based on the tracking my progression and setting up challenges'; 'along with daily stats it also provides tips which are specific to you'; 'daily progress chart'; 'logging of activities'*.

Calories was a popular response from G3 and comments were: *'[...] good to know how much I burned'*; for **distance travelled**: *'I love the stats on the Fitbit [...] weekly totals of (kms) walked'*. For G4 a few responses were: for **distance travelled**: *'I like walking, so distance is important'; 'distance monitoring device'*; for **progression**: *'comparisons to previous similar exercise / i.e. cycling routes same climbs and compare times'; 'show progress or improvement'*.

Negative attributes: Percentages of the negative attributes that affected participation in PA is shown in Table 15. Frequencies and affordances with lower percentages are seen in the Appendix (Table 64).

Age Cat	Negative Attributes
18-29 (n _{att} =9)	Step counters (44.4%), social sharing (33.3%), Points (22.2%),
30-49 (n _{att} =53)	Challenges (17%), step counters (13.2%), badges (7.5%),
50-64 (n _{att} =27)	Challenges (18.5%), step counters (18.5%), calories (14.8%)
65+ (n _{att} =81)	Challenges (17%), time (14.4%), progression (9.9%), personal data (8.6%)

Table 15: Negative Attributes

The pressures of tracking were more of an annoyance causing negative feelings about these affordances as in these comments in G1: *'[...] step-counters- I've never used one and don't care to try [...] seems unnecessary'*; *'[...] too much pressure with counting and maintaining steps [...]'*. With **social affordances** comments made were: *'[...] social aspects don't interest me'*; *'[...] I do not like the pressure of sharing'*.

With G2, a few comments indicating negativity related to **challenges** were: *'[...]the competition side of the physical activities'*; with **step counters**: *'[...]too much time it takes to learn something, too much fiddling'*; for **social sharing** (Table 64) : *'[...]too much social stuff, I don't need to share every time I take a deep breath[...]'*; *'[...]other people don't motivate me, I prefer to work out alone[...]'*; *'[...]Notifications from the app which tell you that your friend is doing better than you, ...really annoying, I feel like that's childish[...]'*.

For G3, a few comments made about the pressures of **challenges** were: *'I do not like competition [...]'*; *'[...] days with little activity are motivating as well because you don't want to have them very often'*. **Step-counters** added increased pressure to keep up: *'...numbers make me anxious'*; with **calories**: *'...I do not want calories to rule my life'*. A few comments made by G4 relating to the pressures of **challenges** were: *'[...]do not like challenges that are tough'*; *'fear of falling'*; *'complex steps'*; *'complex routines'*; *'easy to remember (difficulty)'*; *'fear of exertion'*; *'Intensity of physical activity'*; for **progression**: *'[...]as the day progresses I am less likely to be active or want to start anything'*. There was no mention of personal data and privacy in the responses.

Affordances that facilitate goals for PA: Excerpts of percentages of attributes that *help in facilitating PA* for the groups are shown in Table 16. Frequencies and affordances with lower percentages are seen in the Appendix (Table 65).

Age Cat	Affordances
18-29 (n _{att} =34)	Goals (14.7%), challenges (11.8%), step counters (11.8%)
30-49 (n _{att} =78)	Goals (12.8%), progression (10.3%), challenges (9.0%),
50-64 (n _{att} =65)	Goals (9.2%), Distance travelled (9.2%), challenges (7.7%)
65+ (n _{att} =112)	Goals (8.9%), badges (8%), challenges (7.1%)

Table 16: Affordances that Facilitate Goals for PA

Comments made for **goals** as a motivational affordance facilitating PA for G1 were: *'I'd need to have goals for what I want to accomplish in mind'*; *'[...] calculating goals for me based on diet [...]'*. A few responses for **challenges** were: *'[...] I like to increase difficulty'*; *'[...] like to push myself'*. For **step counters**: *'[...] helps to see where I am at'*; *'how much is completed'*; *'[...] am I on track'*.

Within G2 there were comments combining **goals** and **challenges**: *'[...]the goals that I have for my life help decide my activity goals'*; *'[...] I've used a running app in the past which trains you to reach a specific running goal (5km runs)'*; *'[...] cumulative milestones like run 500 km in a year or other milestones like fastest 10km run'*. *'[...] I prefer to see my progress every time, daily and weekly'*; *'[...] hope to see my steps increase'*, were a few comments regarding **progression**.

A few interesting comments posted by the G3 group with reference to **goals** were: *'[...]prefer to achieve goals'*; *'[...]burn off calories'*; *'[...]benchmark in terms of physical activity expected for age - to compare myself against the benchmark'*. Some responses for **distance-travelled** were: *'[...] see my distance travelled'*; *'my accomplishment per day [...]'*.

Notable characteristics that were suggested as help to facilitate PA **goals** in G4 were: *'[...]simple routines'*; *'[...]easy to remember and recall steps'*; *'[...]I do the same activities over and over*

again'; '[...]age related goal suggestions'; '[...]incremental goals'; '[...]simple steps and routines'. Some responses for **badges** were: '[...] did not take badges seriously, but felt good on seeing a badge'; '[...] image of a trophy felt good'. '[...] pushing myself to do the new hike felt good'; 'did not mind some new ones (challenges) [...]', were some responses for **challenges**.

Continuance of PA: For the answers to attributes that could facilitate continuance of PA over a longer time frame, the top three attributes are as shown in Table 17. Frequencies and affordances with lower percentages are seen in the Appendix (Table 66).

Age Cat	Affordances
18-29 (n _{att} =37)	Badges (16.2%), goals (16.2%), progression (13.5%)
30-49 (n _{att} =56)	Progression (10.7%), step counters (10.7%), time (10.7%),
50-64 (n _{att} =55)	Goals (12.7%), step counters (10.9%), feedback (9.1%)
65+ (n _{att} =86)	Feedback (15.1%), progression (14%), goals (12.8%)

Table 17: Continuance in PA over a longer time

Interestingly, **badges** served as a motivational affordance for G1: '[...]I think virtual badges are neat'; '[...] some kind of game/badge element with goals for completing a given exercise'; 'incentives'; 'stars'; 'badges'.

Progression was an important motivational affordance for G2: '[...]a graphical completion chart'; 'progression history'; '[...]tracking progress of how you are improving'; '[...] tracking over time to show progress'.

A few responses from G3 regarding **goals** as an important affordance for continuance of PA were: '[...]like training targets'; '[...]do nature stuff'; '[...]good heath'; '[...]speed to complete six kilometers of walking per night'; '[...]willingness to have a healthy body'.

Feedback was of prime importance to G4 for continuing to participate in PA: 'Involuntary updates (perhaps weekly) delivered to me with graphic information indicating progress'; 'I

prefer improvements on daily and weekly basis'; '[...]more interaction and feedback on an app like using my Fitbit'; '[...]need feedback on improvements[...]; '[...]advice of family physician'; '[...]praise'.

While **social sharing** (7.5%) (Table 66) had a lower percentage for continuance of PA, a few notable comments regarding this affordance were: *'[...] someone to compete with directly and share [...]; '[...] social linking to track progress easily and participate remotely in shared exercise with friends' (G2); '[...] prefer a consistent social group' (G3); 'I need a social environment for higher motivation to initiate and stick to physical activity' (G4).* The content analysis provided insights into preferences of respondents from the four age groups to certain motivational affordances that facilitate PA or serve as triggers to help foster motivation in PA.

6.5 Survey Study Discussion

This survey study investigated motives to participate in PA and preferences and compared preferences of motivational affordances of adults within four age groups towards technology facilitated PA. Health tracking and gamification of physical exercise are on the brink of becoming part of one's daily routines. However, a range of affordances in these wearable and online applications are generalized for a generic population and are not tailored towards the exercise motivations of specific demographic population. The presumption that the design of these applications could be a universal adaptation of these systems for different age groups is flawed. This survey study helps to shed some more light on this by providing insights into PA motivations by comparing PA motives in four age groups. This survey study also analyzes positive and negative attributes that could help facilitate or hinder technology-facilitated PA. The findings are discussed in the same order as presented in the results section.

6.5.1 Participant Demographics

From the total sample (N=150) it is of note that more than half the sample size (60.1%) spent more than five hours sitting in a day, and slept for 7-8.5 hours in a day (54.4%). A high percentage of the sample did not play any digital games (52%). Of those who played digital games, smart phones (35%), tablets (22.3%) and cell-phones (11.7%) were the most desirable media with which to play. Additionally, while a high percentage of the sample spent less than an

hour participating in PA (28%), did not use any apps (71.3%) or devices to monitor their PA (60.7%), Fitbit (19.1%) and pedometers (17%) were most favoured by the remaining respondents. The survey data indicates that of the respondents who played digital games, mobile devices were preferred for digital games, and wearable tracking devices were preferred technology choices.

6.5.2 Comparison of Motivational Differences between Age Groups

In this study, the 51 scale items were reduced into the 14 dimensions as suggested by the EMI-2 literature (Markland & Ingledew, 1997). The 14 dimensions for motives to participate in PA had high reliability. Non-parametric tests revealed significant results only for the health pressures and ill health avoidance dimensions. Based on the EMI-2, this result indicated that advice from doctors, preventing illness prevalent in the family and recovering from an illness took precedence over scale items from other dimensions. Similarly, avoidance of heart disease, preventing health problems, avoiding ill-health and staying healthy were indicative of the significant results within the ill health dimension.

Furthermore, pairwise comparison between two groups (using G1 as control group) revealed significant results for the three other age groups in the health pressures and the ill health avoidance dimensions. From the younger adults group, the notion of being physically fit and healthy stems from their outlook towards life and perceived lack of health challenges (Molanorouzi et al., 2015; Wilcox et al., 2009). This indicates that these two dimensions were important motives to participate in PA for the three age groups because *health pressures* and *ill health avoidance* issues increases with age (Services, 1996; van der Bij, Laurant, & Wensing, 2002; World Health Organization, 2010).

Results showed statistically significant trend of higher median scores (Jonckheere-Terpstra statistic) within the health pressures, ill-health avoidance, and nimbleness dimensions. This shows the trend of increased relevance of the motives of these dimensions towards participation in PA between the four age groups. This trend can be attributed to being advised by doctors to

participate in regular exercises, the need to overcome the challenges of illness that runs in the family or recover from an injury (Markland & Ingledew, 1997; Mullen et al., 2011).

Furthermore, these findings could also be interpreted as wanting to be on target to lose weight, maintain flexibility and wanting to be more agile (M. Dacey et al., 2008). These findings help to answer the RQ1_{Ph2} about differences in motivation to participate in PA between adults from different age groups.

6.5.3 Motivational Affordances for PA

Content analysis of the long-form text from the survey showed: The most popular *type of feedback* referred by age group 1 and 2 was feedback on *calories*. *Time* taken to complete a task was a popular feedback preferred by group 3, whereas *step counters* was popular with the older demographic. This relates to the possibility of more walking done by the participants in group 4 resulting in *distance travelled* coming in as the second most favourite type of feedback preferred by this group. This means that these types of feedback elements can be a greater focus when designing an app to facilitate PA for these age groups. The least favoured type of feedback was achievement, choice, cost (G1); weight loss (G2); achievement, cost, distance travelled and sound (G3) and achievement, cost, sharing and weight loss for G4. This could be because while younger adults (G1) liked badges as indicated in the following discussion, the possibility of every activity as a challenge could make the aspect of an achievement to be commonplace. For the middle-aged group (G2), even though feedback on calories was welcomed, being reminded about weight loss as a measure for being fit could be frustrating in itself. In the same vein, while time as feedback was welcomed by G3, distance travelled as a metric could be a reminder of more achievements to be undertaken. For G4, the aspect of unnecessary sharing of small achievements could also be an indicator of idle conversation and attempting to feel good for a small amount of effort done.

In terms of *motivational affordances to facilitate PA*, the most popular affordances were *badges* and *progression* for age-group 1. *Calories* were popular for G2 and G3 with *step counters* again being a favourite for Group 4. This indicates that extrinsic motivational affordances were more popular with the younger age-group indicating their excitement in collecting badges and points

(Forde, Mekler, & Opwis, 2015; Zuckerman & Gal-Oz, 2014) and tracking metrics were more favoured by the G2, G3 and G4. The least popular motivational affordance was trailing feedback (G1), competition, comparing with friends and negative feedback (G2), competition and comparing with friends (G3), and levels for G4. This finding implies the reluctance of participants in G2 and G3 to share their performance and metrics with others and the reluctance of the older age group (G4) to be inundated with unnecessary complex routines for PA or difficult levels.

From the perspective of *negative attributes*, *step counters* (G1), *challenges* (G2, G3 and G4), were the least favourite of the motivational attributes. *Time* was also one of the negative attributes for G4, which also implies that the time taken for PA by this group was a negative pressure for the survey respondents.

For the question regarding *attributes that aid/facilitate goals for PA*, the survey response indicated a selection of motivational affordances. *Goals* (G1), *challenges* (G2), *choice* (G3) and *goals* (G4) were the most popular of the attributes. This finding does not relate with the *negative attributes* finding for G2 because *challenges* were indicated as a *negative attribute* by respondents in G2. Further investigation of the responses indicated that respondents were averse to *challenge pressure* (negative attribute) as opposed to challenges as an attribute. The least favoured attribute was *achievement* (G1), *sound* and *device* (G2), *narrative* (G3) and *sound* and *calories* for G4. One respondent (G3) was quite interested in narratives but indicated that relevance of the narrative was important to the context of the app design.

From a physical activity or exercise adherence (*continuance of PA over time*) perspective, *badges* (G1), *progression* (G2), *goals* (G3) and *feedback* (G4) were key favourites within each category. Feedback as a generic term was indicated to be meant to get feedback on improvements, form checking and gait for G4. Lack of a form-checker and speed display (G1), cost (G2), lack of speed display and quests (G3), and lack of control over confidentiality of health data as in privacy of personal information were the least favorable of attributes which could hinder participation in PA. This also implied that respondents in G1 were not keen on form checking and speed as opposed to concerns of privacy of health data from G4. These findings

describe in detail the differences in motivational affordances preferred between the four age groups answering the RQ2_{Ph2}.

6.6 Age-group-specific Design Guidelines

This survey study focused on comparing the motivation to participate in PA between four age groups and investigating the preferences for motivational affordances in PA facilitated by technology. While motivation to participate in PA differed significantly in the health pressures and ill-health dimensions of the EMI-2, content analysis of long-form survey questions provides design guidelines for tailoring motivational affordances by age groups. These age-group-specific design guidelines on basis of the long-form survey questions are categorized further into motivation to participate in PA, facilitating goals for PA, and continuance of PA. The following design guidelines as shown in Table 18 are suggested for designing age-differentiated PA technology.

Age Cat	Design guidelines for PA technology
18-29	<p>Motivation for PA: While fostering intrinsic motivation through affordances like goals and progression, it is also critical to integrate extrinsic motivational affordances like badges and rewards.</p> <p>Facilitating goals for PA: Incorporate accomplishment affordances while fostering challenge within the context of PA</p> <p>Continuance of PA: Provide the opportunity to earn badges and rewards while working towards goals</p>
30-49	<p>Motivation for PA: Incorporate feedback elements like calories and distance travelled while providing daily progression and comparisons with social circle.</p> <p>Facilitating goals for PA: While integrating a combination of short term goals/long-term goals, and challenges, provide progression affordance in the form of reaching milestones</p> <p>Continuance of PA: Integrate progression in the form of visual graphs to show progress over time and achievement of goals</p>
50-64	<p>Motivation for PA: While integrating feedback elements like calories and distance travelled to facilitate walking, it is suggested to incorporate weekly progression elements to foster intrinsic motivation.</p> <p>Facilitating goals for PA: Provide the opportunity to achieve goals with provisions of comparing with benchmarked PA markers</p> <p>Continuance of PA: Provide opportunity of setting up goals with feedback on progression</p>
65+	<p>Motivation for PA: Provide monitoring of activities to encourage walking using feedback elements like step-counters and distance metrics while indicating progress or improvement as affordances from a feel-good perspective.</p> <p>Facilitating goals for PA: Integrate simple routines and challenges while providing opportunity to earn badges</p>

Age Cat	Design guidelines for PA technology
	Continuance of PA: Integrate feedback elements to provide involuntary feedback, praise and improvement

Table 18: Design Guidelines to Integrate Affordances

6.6.1 Motivational Affordances and Feedback/Tracking Metrics

From a technology facilitated PA solution perspective, it is important to distinguish between gamification elements and feedback/tracking metrics (Table 19). Content analysis findings indicate the relevance of gamification elements as motivational affordances. A few of these intrinsic elements that were gleaned from this analysis are: goals, challenges, progression, achievements, choice quests, and social sharing leading to a feel-good context. Extrinsic elements such as badges, rewards, incentives, points, and leaderboards were also key findings within this survey study. As indicated by research, many of these extrinsic elements would also foster intrinsic motivation (M. Dacey et al., 2008; Juho Hamari & Koivisto, 2015b; Mekler et al., 2013).

Many levels of feedback elements or tracking metrics of PA activities also serve as motivational affordances in a technology facilitated PA situation. A few of these feedback types from the findings are: calorie tracking, step counters, distance travelled, daily notifications, time spent, heart rate, breathing rate, speed, sleep cycle, sound inputs and weight loss indicators. Additional, attributes such as physical form checking, posture correction and gait were also desirable attributes as presented in the survey responses.

Motivational elements	
Gamified motivational affordances (Intrinsic elements)	Goals Challenges Progression Achievements Choice/options Quests Social sharing
Gamified motivational affordances (Extrinsic elements)	Badges Rewards Points Incentives Leaderboards

Motivational elements	
Feedback Elements	Calorie tracker
	Step-counters
	Distance travelled
	Daily notifications
	Time spent
	Heart rate
	Breathing rate
	Sleep cycle
	Sound inputs
	Weight loss indicator
	Physical form checker
	Gait/posture checker

Table 19: Differentiating Gamified Motivational Affordances and Feedback Elements

6.6.2 Motivation for PA-Motivational Affordances-PA Technology

While prior studies have shown that motivation for PA has an intrinsic and extrinsic component (M. Dacey et al., 2008; Dishman & Ickes, 1981; Markland & Ingledew, 1997), this survey study indicates that the driver for fostering participation in PA is the need to remain healthy and maintain good health. Additionally, while the presence of literature in the domain of motivation and PA is available, there is no comparison of PA attitudes/motivations by age from the standpoint of technology-assisted PA and motivational affordances. This study addresses this gap by comparing age groups, triangulating PA motivation, and motivational affordances for PA technology, and PA. To the best of my knowledge, this triangulation has not been studied in any of the literature.

For PA, these findings help identify and differentiate motivational affordances between the four age groups of adults. Findings also help to differentiate feedback/tracking metrics from gamification elements, thereby helping to minimize confusion in the use of gamification elements and feedback/tracking elements. While both these elements serve as motivational affordances for participation in PA, they are distinctly different in its function and usage as explained in the earlier subsection (6.6.1).

Applications serving as technology facilitators for PA will need to use this distinction diligently and implement gamification and feedback/tracking elements. While feedback is a generic term and is a gamification element, the content analysis indicates that it is important to include feedback elements in the form of tracking PA from feedback within a gamification context. This differentiation will help designers to establish gamification elements and feedback/tracking elements for PA facilitated by technology.

6.7 Limitations and Future Research Directions

While the survey study had many participants, G1 had only 17 participants compared to the higher participant numbers in G2, G3 and G4. As such the small sample size of this categorized age-group may be a limitation to this study because in an ideal situation, all four groups should have the same number of participants to make an effective comparison. Furthermore, surveys have their own limitations due to the number of questions presented to the participants. Many questions from the EMI-2 and long form questions could have also led to fatigue during the survey answering mode. While this survey study helped to understand the overall preferences of respondents within these categorized age groups, an interview based qualitative study over a longer period of time would be needed to understand detailed motivational affordances (intrinsic and extrinsic) that facilitate PA. This would also allow for understanding the changes in motivational affordances over time.

These findings can be used to investigate specific motivational affordances and tracking metrics for select age groups, so as to enable identification and evaluation of gamification elements, tracking elements or feedback metrics. Additionally, the influence of these motivational affordances (intrinsic and extrinsic) can lead to a better understanding of its applicability and its influence on intrinsic and extrinsic motivations to participate in PA. Further investigation on feedback and tracking metrics needs to be done so as to enable a distinction between gamification elements and feedback attributes or metrics to facilitate PA.

6.8 Summary

While health technologies and gamified fitness strategies have been widely adopted by many, little research supports the differentiation of technology assisted motivational affordances for PA in specific age groups to maintain PA routines. This study fills this gap and contributes to advancing knowledge in the design of gamified PA technology, a realm of human computer interaction on many levels. Firstly, this study provided evidence that health pressures and ill-health avoidance were significant influencers to participate in PA in the age groups compared. Secondly, this work provided new insights to differentiating motivational affordances to be tailored for different age groups, with the goal of helping researchers and designers to better understand design challenges when creating PA applications for different age groups. This is an important step in the development of meaningful health technology applications for adults, young and old. This would allow designers and researchers to apply gamified technology in the initiation, maintenance and adherence of PA that promote physical and mental well-being. More work is necessary to survey attitudes and behaviour change facilitated by technology-supported physical activity among adults of different age groups. Thirdly, findings from this research identified a differentiation between gamified motivational elements and feedback elements and provided age-group-specific design guidelines which are critical for customizable and tailored technology for PA. This is a valuable contribution to the growing body of work in human-computer interaction.

Chapter 7

7 Phase 3: Spirit50 Design, Development and Testing

A comparison of gamification apps for PA technology revealed that challenges of aging related to physical ability were not taken into consideration. These apps and gamified technology were not designed with older adults' physical challenges due to aging. This comparison is shown in Appendix 13.5. Due to this reason, I decided to develop a gamified PA technology specifically tailored and customized for older adults' needs and wants. Based on preliminary studies (Chapter 5) and the EMTF (Section 5.6), these needs and wants were further categorized into vague-goals, specific-goals, barriers and current health conditions.

7.1 Spirit 50 Design

Spirit50 was a technology artifact designed using the EMTF (Section 5.6) and developed to provide customised and personalised exercise routines to older adults. This artifact was tailored to their motivations to exercise and catered to older adults PA with considerations to the physical and technological barriers commonly experienced by an older demographic. For the Spirit50 application development phase, the development team comprised of one interaction designer (me), one programmer, one database design specialist, one student for quality checking and data entry, and my supervisor.

I was responsible for the overall design strategy, systems design, interface design, planning and design strategy for the database design for the Spirit 50 fitness application. Additionally, I had the advantage of working on this application through an NSERC Engage Grant (GP #463454-14) with Vintage Fitness as a client. Spirit50 was specifically designed for adults over 50 years of age which incorporated the following gamification elements: goal definition (quest), daily challenges, goal progression meter, points and badges (stars) as motivational affordances (gamification).

The methodology for designing and developing technology artifact used all aspects of the EMTF framework. The application was beta tested and user testing sessions helped to overcome usability and interaction issues. These are detailed in this chapter. The development of Spirit50 and evaluation with six participants (users) helped us implement and evaluate EMTF for older adults in a real-case situation. This allowed the development team to investigate the framework for ease of applicability and potential shortcomings. This chapter presents valuable lessons learned in evaluating Spirit50 with older adults from the perspective of workflow design, interface design and interaction design.

7.1.1 Database Design and Development

The EMTF further provided the basis to build a knowledge database (Figure 23 and Figure 24) which was developed in consultation with fitness experts with over 10 years of field experience with physical training of older adults. The patterns of daily exercise routines were categorized based on a collection fitness goals identified as vague goals and specific goals from the EMTF. There existed a one-to-many relation between vague goals (long-term goals) and specific goals (short-term goals). These relations are indicated in the Appendix (Section 13.2)

As part of the NSERC grant, due to time and resource constraints, it was decided to develop fitness roadmaps for only 10 specific goals. These specific goals were selected based on the patterns provided by fitness experts regarding the most common challenges faced by older adults (Appendix 13.2). Fitness experts helped to develop daily exercise routines for an eight-week period for each specific goal exercise routine. Four to five individual exercises combined together to form a daily exercise routine (daily program). Daily exercise programs together for the week represented weekly exercise roadmaps. Patterns of exercise routines for weekly schedules were termed “exercise roadmaps” and comprised of various daily routines involving several hundred different exercise variations. These variations were presented to the user (client) based on their selection of vague-goals, specific-goals, barriers, and current fitness health conditions.

For each specific goal that was selected for development, the corresponding fitness programs for daily and weekly iterations were developed and were integrated into the database to be represented in web application. These exercise roadmaps (programs) were provided in a

simplistic manner in the web application and were available for selection by older adults (10 programs x 3 intensity levels x 8-week package x 7 days of a week = 1680 daily exercise routines). The online application integrated a custom database to manage the content of the exercise programs delivered via a web interface that allowed personalization and customization of fitness activities based on user selections of their motivations. The beta version of the online application was functional to be deployed on desktops, laptops or tablets. A WordPress design that integrated with a MySQL database was developed to display the frontend of the application and display various selections and instructions to the user.

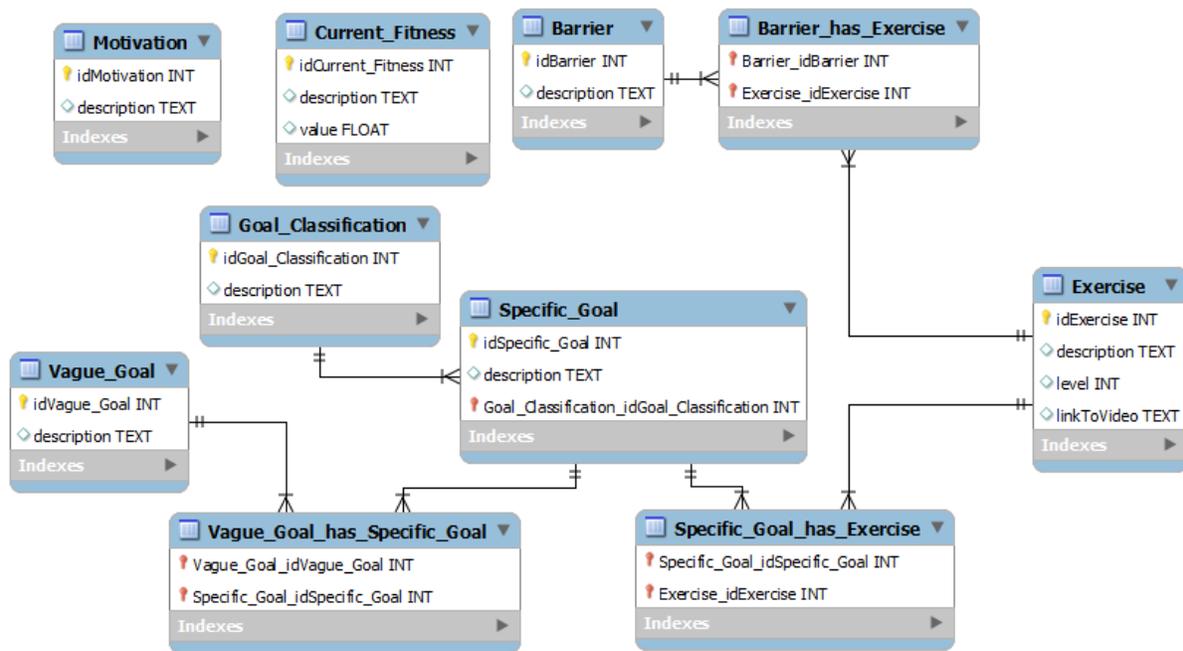


Figure 23: Knowledge Database

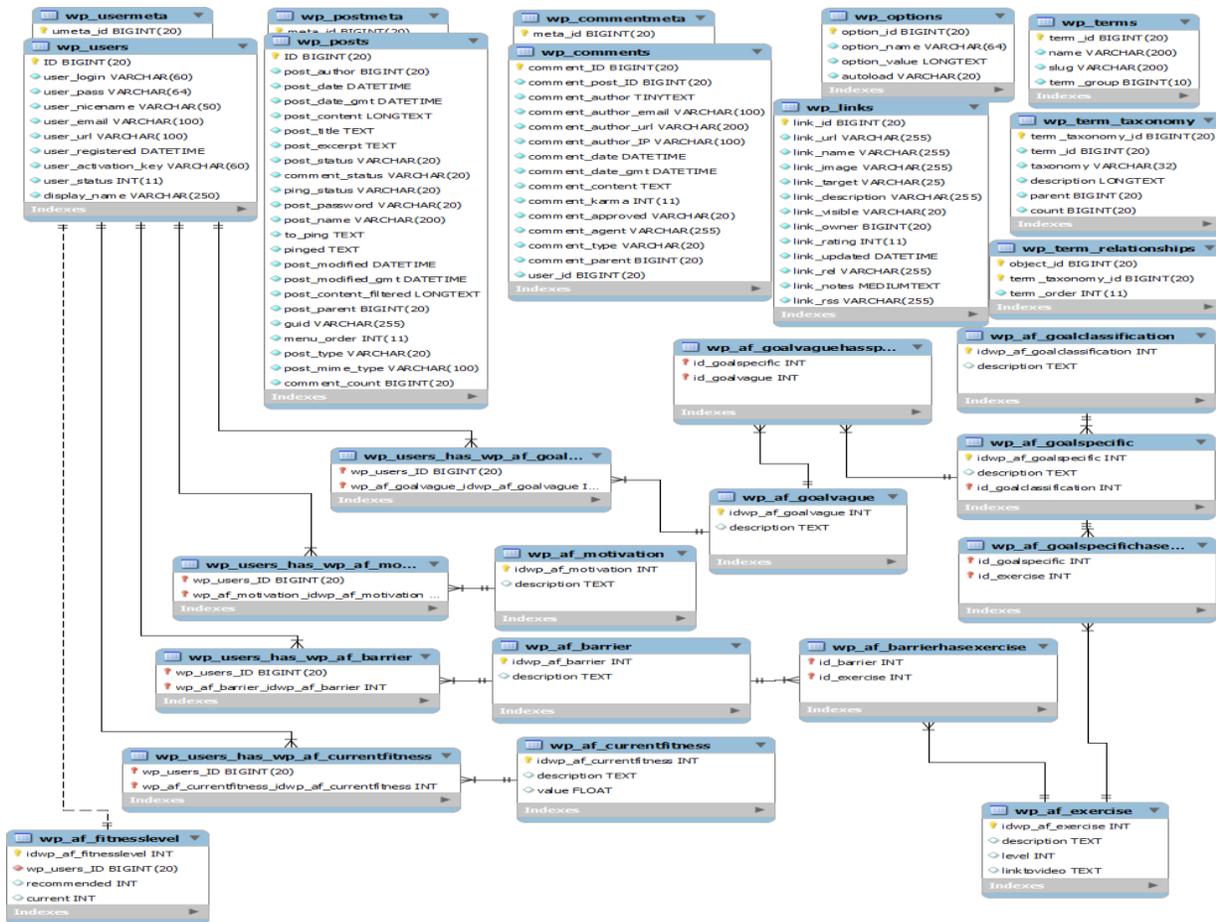


Figure 24: Database Structure

7.1.2 Gamification Plan

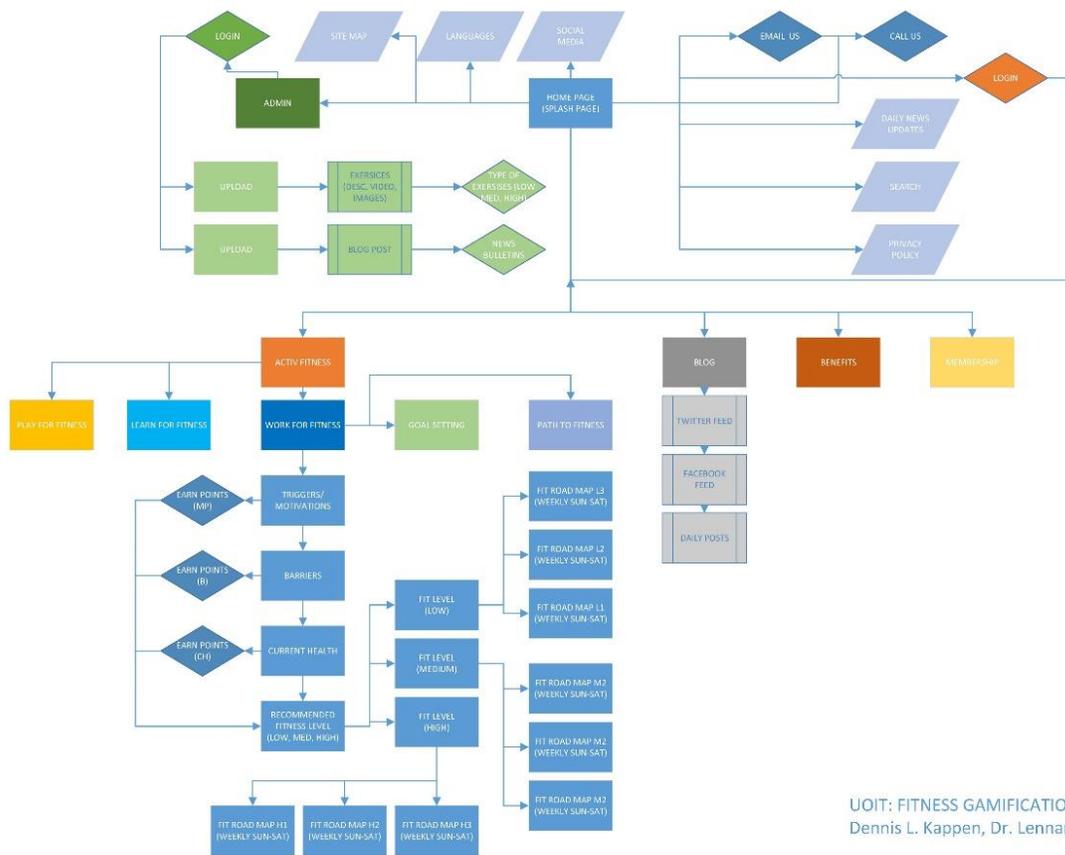
Spirit50 represents a goal-based exercise plan for older adults leading to assignment of exercise (fitness) roadmaps for an eight-week period. Spirit50 leverages the concept of gamification inspiring older adults to seek out their intrinsic motivations for participating in PA. From an intrinsic motivation perspective, the SDT and KEG dimensions was used to segregate the vague-goals and specific-goals into autonomy, competence and relatedness (Appendix 13.2).

Theoretical Construct	Gamification Elements	Description
Intrinsic Motivation	Goals (Quests)	These represented vague-goals and specific-goals differentiated based on autonomy, competence and relatedness
	Daily Challenges	Exercise challenges for the day
	Weekly Challenges	Visual mapping of the weekly exercise challenges

	Accomplishment	Set collection of daily and weekly tasks
	Goal progression	Mapping of progressing over an eight-week period
Extrinsic Motivation	Stars (Badges)	Bronze (daily exercise routine completion), Silver (weekly exercise routine), Gold Star (completing the exercise plan)
	Points	Receive points for completing an exercise
	Check-mark	Task completion check-mark
Feedback	Accolades	Kudos for task completion
	Check-mark for task completion	Visual check-mark for exercise completion
	Roadmap check-mark	Visual check-marks for daily and weekly exercise completion
	Videos	Start and stop videos showcasing the proper exercise technique
	Time taken	Time taken to complete the exercise routine
	Reps and Steps	Number of reps and steps of the individual exercises
	Provide self-pointers or goals	Feedback from user

Table 20: Spirit50 Gamification Plan

Integrated tools allowed users to track their progress and access instructional photos and videos to assist them in meeting their fitness objectives. Based on the selection of motivations (vague-goals), barriers to PA, and current fitness health conditions, a fitness schedule with specific exercises and beneficial tips were recommended. This fitness schedule was customised for each participant because the selections by the user enabled the algorithm to identify a high, medium, or low intensity level exercise routine specific to a goal chosen by website user (i.e., an older adult). This application used gamification elements to participate in goal based motivational PA objectives (quests) which were characterised by exercise routines, leveling-up, points, achievements, progression, rewards mechanism and self-improvement quests from a fitness training and maintenance perspective. It was developed to provide customized and personalized exercise routines for older adults.



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Figure 25: Application Flowchart

Figure 26 shows the application screen where the users set up their goals. Figure 27 represents the screen where they are encouraged to input their barriers to PA. Figure 28 represents the screen where they answer questions regarding their current health conditions. The participant reviewed multiple choice questions on challenges relating to BPA like: the head and neck, upper body, arms, lower body and legs. The categorization of challenges for BPA was defined by fitness experts and was based on their experience with training older adults. The questions for the challenges pertinent to each BPA were created by these experts. Additionally, questions were based on their assessment of current health conditions of the clients on a one-on-one basis, prior to designing an exercise package in their real-time training facilities.

Figure 26: Setting up Goals

Figure 27: Setting up Barriers

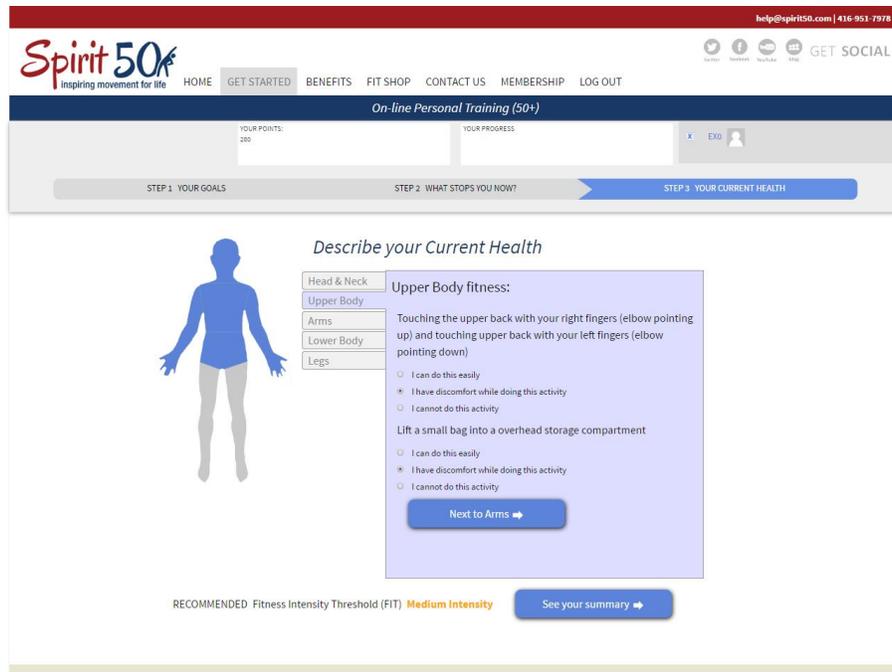


Figure 28: Setting up of Current Health Conditions

Selection of the summary button provided users with information about their vague-goals, barriers and current health conditions. This summary screen (Figure 29) prompted the user to select from a choice of specific-goals associated with the vague goal.

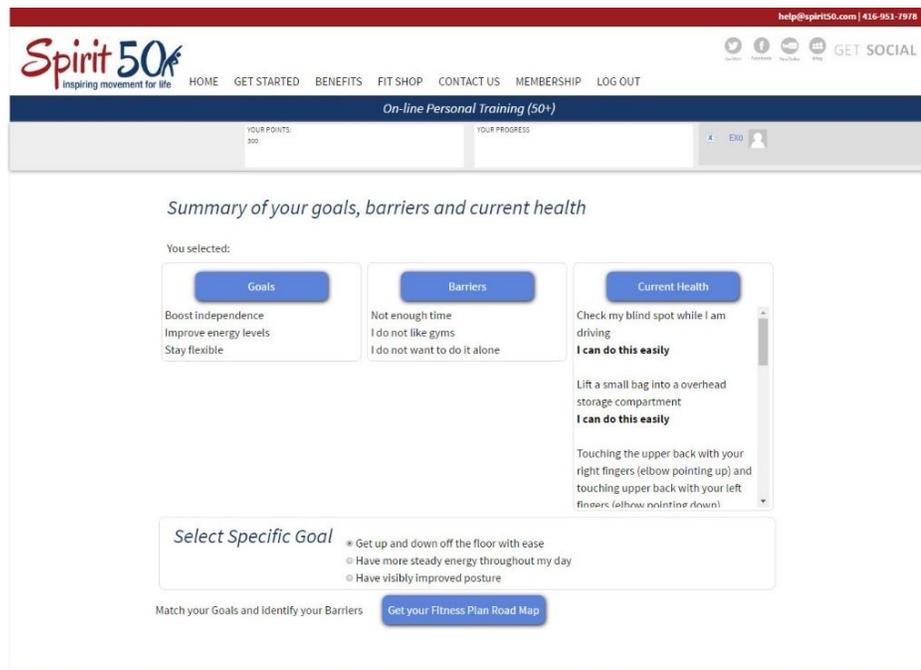


Figure 29: Summary Screen

Once the user selected a specific goal, an exercise roadmap (Figure 30) for an eight-week period was provided with exercises that are active for the current day of the week.

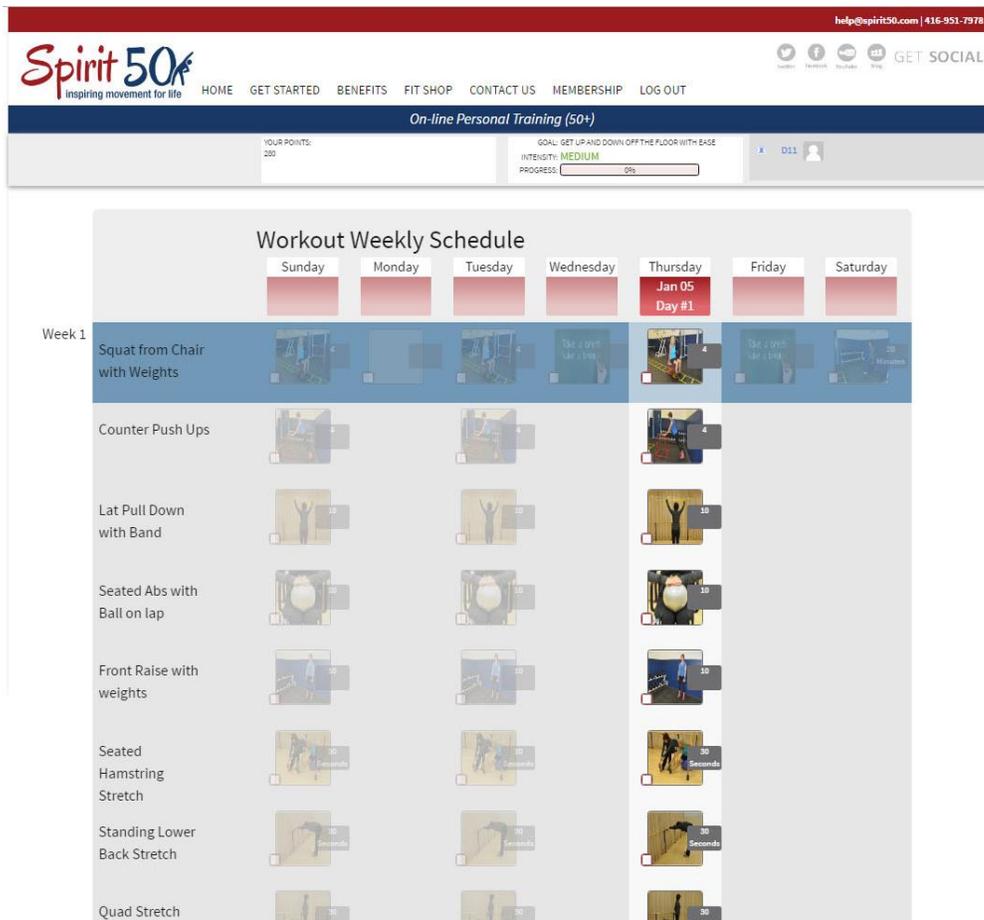


Figure 30: Exercise Roadmap

The participant is supposed to click on any of the daily exercises in any order and do the exercise as indicated in the example shown in Figure 31. For each exercise that is completed, the participant received points for task completion. The completed exercise received a check-mark indicating task completion. Accolades such as a visual clap and good work were also provided in the form of random visuals and were intended to be encouragements for the user. The participant was supposed to cycle through all the exercises provided for a specific day to accumulate the maximum points for a specific day of the week. Stars were awarded to the participant based on the sequence provided in Table 20.

The next day on the fitness road-map presented a new set of daily exercise challenges. Each week, the reps and steps for the standard exercises would increase, thus adding to the challenge

level of the weekly exercise routines. Additionally, certain specific goals would also have new exercises interspaced randomly within the daily exercises. This was intentionally done to break the monotony of the weekly routines.

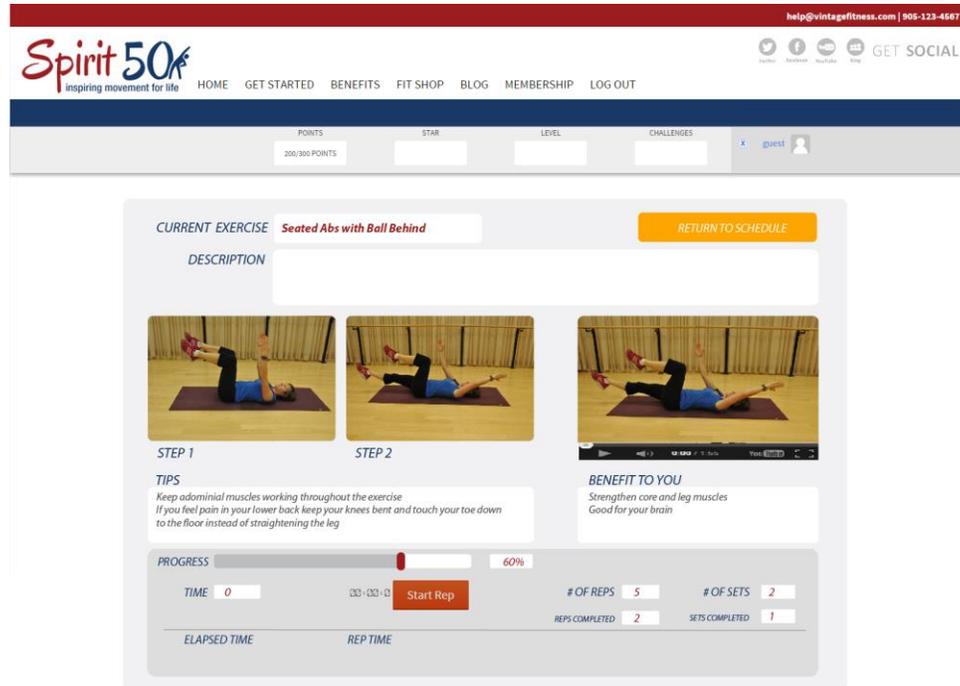


Figure 31: Individual Exercises

7.2 User Testing

Participants and Materials:

Participants were recruited from the list of current clients engaged in receiving personal training from Vintage Fitness, family members of UOIT students and friends. The testing of the Spirit50 technology artifact was conducted in an iterative manner congruent to the DSR methodology (Section 4.1). Based on this I decided to evaluate Spirit50, a gamified technology artifact, in stages to provide feedback on the usability of the artifact. I conducted user testing sessions to evaluate the usability of the Spirit50 application.

Evaluation with six users (mean age = 66.6) enabled product improvement after each user test iteratively. Two user evaluations were conducted in the homes of older adults so as to enable their access to the Spirit50 web artifact within the confines of their own personal spaces.

Feedback from these sessions were used to modify the interface design and clarity of the design elements, which took two weeks to implement. Another two user evaluations were carried out at the Centre for Elder Research in a laboratory setting. Feedback from these sessions provided feedback on the progression bar, clarification about the types of exercises, and the relation between vague-goals and specific goals. These modifications took three weeks to complete. Another two evaluations were conducted at the experimental lab facility of the HCI Games Group at UOIT. The testing was done on a Dell laptop. Each user session was recorded with a SONY HD (240GB) video camcorder. Participants were not paid for their time but were provided with a free membership of the Spirit50 website application for a period of 8 weeks.

Procedure:

Participants were welcomed and once the informed consent form was signed they were provided with a user name and password and were asked to participate in the questions provided on the Spirit50 website. A talk-aloud protocol was used to capture their thoughts on the videorecorder. The selection of vague goals, specific goals, current fitness health conditions and barriers to participating in PA provided the participant with a collection of exercises to be done in a certain order. Each participant had to follow the instructions pertinent to specific exercises and perform the exercises. The participant had to perform this activity only once at the initiation phase of the Spirit50 web application so that the system could create a customised fitness plan for a two, four or eight-week period. Once the fitness plan was set up, the participant had to follow the instructions provided on the screen and perform the exercise routines for the first day. Each user testing session lasted for one hour. Furthermore, each participant had to follow the instructions pertinent to the weekly fitness plan, review the daily activities and specific exercises and perform the routines at home. A follow-up of their experiences was reported via e-mail.

7.2.1 Findings

A summary of modifications based on the user testing feedback is provided in the table.

Test	Feedback
T1, T2	<p>Workflow Design: modified information flowchart sequence to help with better understanding of goal selections</p> <p>Interface Design: font size, page layout modifications, clustering of rewards information per page, simplifying goal selection page</p>

Test	Feedback
	Interaction: modified click through between videos and exercise information, handling of stopwatch information for each exercise routines, modified rewards mechanisms
T3, T4	<p>Workflow Design: modified rewards mechanism levels, achievement levels from fitness routines, simplified steps for fitness roadmap</p> <p>Interface Design: provided more tangible rewards like stars to indicate achievements, simplified terminologies, simplified progress bar</p> <p>Interaction: reduced the number of clicks required by the user to initiate an exercise, completion of an exercise to be marked as an achievement</p>
T5, T6	<p>Workflow Design: modified BPA figure and the sequence of steps for each BPA</p> <p>Interface Design: provided explanations for exercise routines on mouse overs, decreased spacing between elements</p> <p>Interaction: simplified goal selection, reduced exercise steps and timer settings</p>

Table 21: Summary of Modifications

The analysis of each user testing session helped me to evaluate and provide modifications to the Spirit50 website. I was responsible for the experimental setup, recording the user testing sessions, analysing the recordings and creating a feedback documentation for the design modifications required to be done on the Spirit50 application.

7.2.2 Discussion and Lessons Learned

In an increasingly digital world, it can be difficult to engage an aging population in the online marketplace while ensuring effective, clear communication with customers and an easily understandable user interface. To develop solutions which are intuitively useful and create value for users in the target demographic, Spirit50 proposes a novel approach integrating the concept of gamification to PA participation, specific to the older demographic from a goal based motivation perspective. First and foremost, the development of the Spirit50 web artifact allowed us to implement the EMTF, which posited the segregation of complex goals into vague goals and specific goals. The framework implementation helped us to categorize numerous goals (motivations to participate in PA), identify barriers (mental and physical) to participate in PA and link with current fitness health conditions of older adults. These selections further helped us

connect the exercise intensity levels (high medium or low) to customised fitness routines geared towards strength endurance or flexibility.

The feedback from each user testing session helped to evaluate and modify the Spirit50 application in an iterative process. User testing provided valuable feedback about information workflow and helped to improve the application. The testing also gave feedback regarding the challenges faced by older adults in navigating the instructions provided on the screen and following through by doing the physical activity routines. The disconnect between the research terminologies used for the interaction activities by the research group and the participants was also challenging. These required discussions with the participants after the user testing to investigate their understanding and explanation of the workflow stages. This process helped to simplify the terminologies used in the Spirit50 application.

While the sample size for the user testing was quite small, the testing helped to analyze the user's interactions with the Spirit50 application. The lessons learnt are indicated below:

- Helped to understand the challenges faced by the users regarding terminologies used in the application
- Indicated the challenges with the location of the navigation buttons and location of images
- Helped to identify expectations of the user from their perception of usage and the actual work flow of the application
- Identified programming defects and database functionality issues
- Helped to understand the expectations of the client (Vintage Fitness) to see if the application met their business requirements.
- Helped to gain valuable insights by deploying the application with *active lifestyles*
- Helped to check if the functionality of the application met the needs of the client and the user (participant)
- Helped to determine user account creation and corresponding database challenges.
- Helped to identify fitness roadmap rendering and rendering of visual information regarding exercise routines.

Chapter 8

8 Phase 4: Experimental Study

This study was conducted to investigate motivational affordances in PA technology over a longer period. This was undertaken to understand older adults' preferences and challenges with motivational affordances in a randomized controlled study. Materials from this chapter have been selected for publication in a peer-reviewed conference proceeding and has been reproduced under License to use from IEEE (Appendix 13.13.4).

Dennis L. Kappen, Pejman Mirza-Babaei and Lennart E. Nacke. 2018. Older Adults' Physical Activity Gamification: An Eight-Week Study. In *Proceedings of the Annual Hawaii International Conference on System Sciences-51, IEEE*, 1-10

8.1 Eight-week Experimental Study Comparing PA Technology

The factors that motivate older adults to participate in physical activity (PA) is greatly influenced by their age-related impairments and health related challenges (M. Dacey et al., 2008; Fife, 2008; Schutzer & Graves, 2004b). Motivations to engage in PA is also influenced by their own personalities, attitudes towards technology and social interaction (Kuroda, Sato, Ishizaka, Yamakado, & Yamaguchi, 2012). More research is needed to provide insight into designing and tailoring fitness programs for older adults from a motivation and goals based initiative as opposed to a point based system. This research will help us investigate the efficacy of implementing motivational affordances through gamification technologies in a new domain of older adults' health and wellness where a sedentary lifestyle is a silent killer.

8.2 Motivation to participate in PA

While older adults with age 65 years and older have been categorized as seniors or elderly, many studies in the canon of research on physical activity interventions have qualified older adults to be 50 years and older (A. C. King, 2001; A. C. King & King, 2010; A. C. King et al., 1998; Weber & Sharma, 2011). One of the many reasons for researching PA activity for this demographic is because many individuals ≥ 50 years do not meet the national guidelines for PA (Brawley et al., 2003). Although many researchers have studied motivation to participate in PA

(Bethancourt et al., 2014; Chase, 2013; M. Dacey et al., 2008; Mullen et al., 2011; Schutzer & Graves, 2004b; Stathi, Fox, Withall, Bentley, & Thompson, 2014), there is limited research and investigation on this subject as it relates to technology facilitation of PA for older adults.

A long-term efficacy study of computer tailored physical activity intervention for older adults carried out on adults over 50 years was effective in inducing long-term behavioural changes in PA of older adults (van Stralen, de Vries, Mudde, Bolman, & Lechner, 2011). The efficacy of print-based intervention was stronger than web-based intervention in adults over 50 years, measured over a 12-month period. This indicated the need for improved web-based interventions for better sustainability of PA over the long term (Denise Astrid Peels et al., 2013). Research also indicates that baby boomers those aged 50 to 64 are increasingly more adept at using web applications and technology artifacts (Irvine et al., 2013; Keenan, 2009; Mouton & Cloes, 2013). This indicates the need to explore the usage of novel strategies like gamification applied to the PA domains.

8.3 Research Design

In comparison to existing PA technology available commercially (Section 13.5), the rationale for selecting Spirit50.com as a technology intervention for this study was because it was a gamified fitness activity intervention website for use by older adults. Spirit50 was specifically designed for adults over 50 years of age and incorporated the following gamification elements: goal definition (quest), daily challenges (sub-goals), goal progression meter, points and badges (stars) as motivational affordances (gamification). Using pedometers was considered to be the second type of PA intervention to be used as a non-gamified technology intervention.

Based on prior literature a minimum effective exercise program for habit formation was six weeks (Kaushal & Rhodes, 2015; Martinson et al., 2010; van der Bij et al., 2002). Therefore, PA over an eight-week duration was studied in a randomized controlled study. The experimental study was a synchronous, three-condition, eight-week study with a total of thirty participants. Participants above 50 years of age were randomized to one of three conditions:

1. Physically active and use a gamified physical activity app (Spirit50.com)

2. Physically active and use a pedometer
3. Physically active (control group)

History and maturation are critical threats to the internal validity of any research design (Fisher & Foreit, 2002). All three groups had participants who were physically active. The inclusion of a control group was done to make effective comparisons the two groups receiving the intervention.

8.3.1 Measures for dependent variables

A prior systematic review on the enjoyment of digital games attributed the experience of enjoyment as key to engagement in digital videogames (Boyle, Connolly, Hainey, & Boyle, 2012; Mekler et al., 2014). Boyle et al. (2021) and Mekler et al. (2014) conceptualised the subjective experience of engagement as a moment-to-moment feelings of enjoyment that players experience while gaming (Boyle et al., 2012; Mekler et al., 2014). Game enjoyment has been equated with the experience of flow as in the state of immersion or an experiential state of play when interacting with the gaming system (Boyle et al., 2012; Douglas & Hargadon, 2000; Jennett et al., 2008; Kort & Ijsselsteijn, 2008; McLaughlin, Gandy, Allaire, & Whitlock, 2012; Mekler et al., 2014; L. Nacke, Drachen, & Göbel, 2000). The most frequently used measures of enjoyment was the IMI (Mekler et al., 2014). Doing an activity for its inherent satisfaction (intrinsic motivation) (Deci et al., 1994a; R. M. Ryan & Deci, 2000a), as opposed to an external outcome translates to paratelic engagement (Apter, 1991; Lieberoth, 2015; Benard Suits, 1972). Researchers have also used the IMI as a measure of engagement (Boyle et al., 2012; Lieberoth, 2015). Therefore, the IMI was selected as a measure of enjoyment and engagement.

From a motivation to participate in PA, the PNSE scale has been used by researchers to measure perceived autonomy, perceived autonomy and perceived relatedness (Direito et al., 2015; Teixeira et al., 2012; Wilson et al., 2006). Preliminary eligibility to participate in the study was established through the PAR-Q (*Physical Activity Readiness Questionnaire - PAR-Q*, 2002) document. Baseline assessment of current PA condition of each participant was assessed using the International Physical Activity Questionnaire (IPAQ) (IPAQ-Group, 2005). Participants from the three conditions filled in a questionnaire once a week, for eight-weeks, which combined the scales measuring the following dependent variables:

1. Measuring the *enjoyment* and *engagement* of the participants over the eight-week period using the Intrinsic Motivation Scale (IMI) (Description, 1994; Lavigne et al., 2009)
2. Measuring the *motivation* aspect of the participants over the eight-week period using the Psychological Need Satisfaction in Exercise Scale instrument (PNSE) (Wilson et al., 2006)
3. User Experience: Measuring *exertion* using the Rating of Perceived Exertion scale (RPE) (Borg, 1982) after each participant session

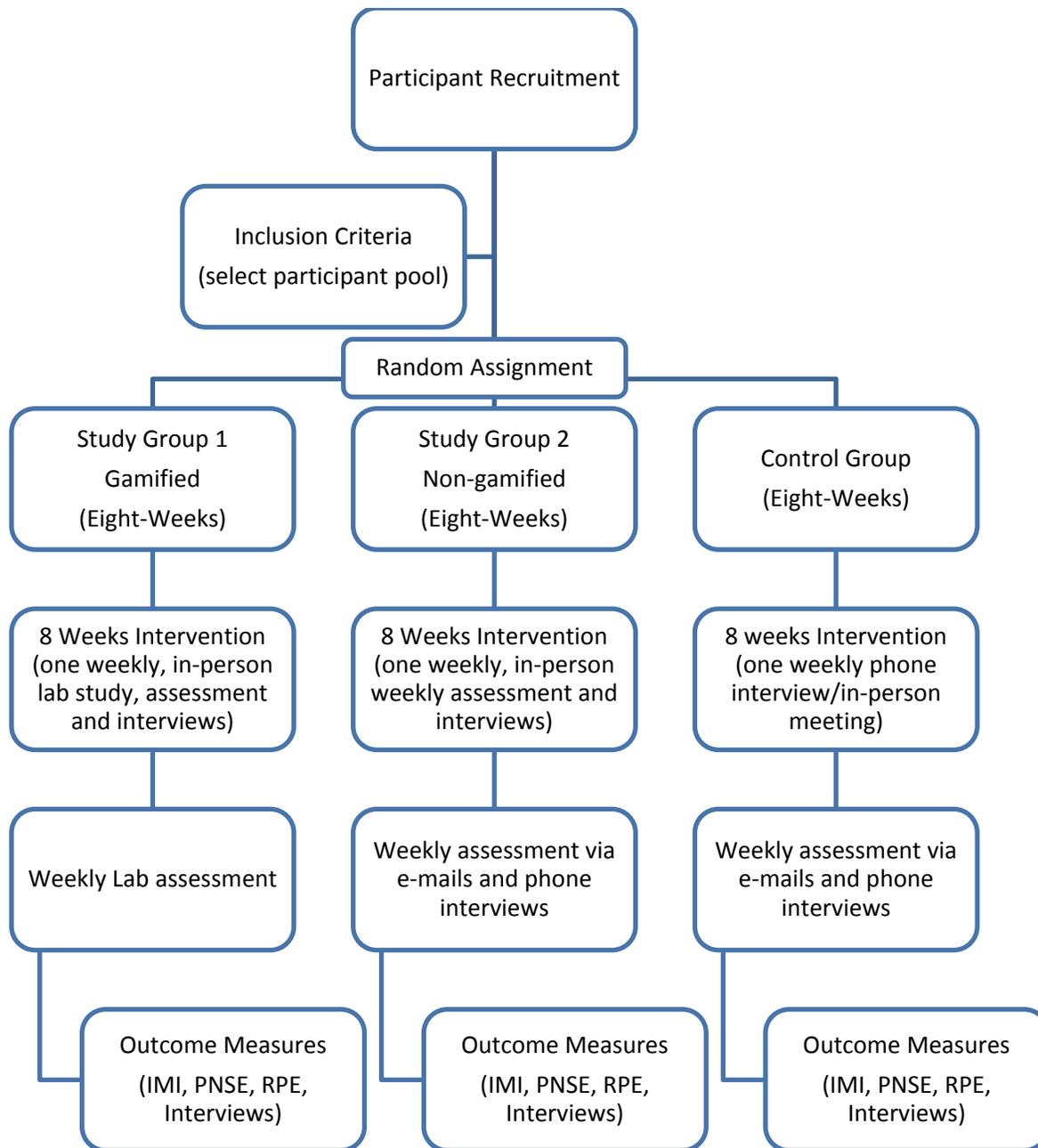


Figure 32: Study Design

Participants were interviewed once a week for the period of the study. Participants from the conditions were also provided the option of being interviewed by phone, Skype or answering the interview questions in an online form.

8.3.2 Participants

Participants over 50 years of age with an active lifestyle as defined by the Dietary Guidelines for Americans, 2014¹⁶ were recruited from the community, where active meant having a physical activity equivalent to walking more than three miles per day at three to four miles per hour in addition to regular daily activities. I refer to individuals living in this manner as *active lifestyles*. Recruitment was conducted through e-mails, flyers, social media postings and in-person. Interested participants were informed about the eight-week commitment and told that they would be randomly allocated to either of the three study conditions. Each participant answered the questions from the Physical Activity Readiness Questionnaire (PAR-Q) (*Physical Activity Readiness Questionnaire - PAR-Q*, 2002) document, which was used to determine their current PA levels and their eligibility to participate in the experimental study. Additionally, the long-form version of the International Physical Activity Questionnaire (IPAQ), a validated instrument (Hagstromer, Oja, & Sjostrom, 2006; IPAQ-Group, 2005) was used to determine the current intensity of PA levels of all participants (Appendix 13.7). A demographic questionnaire was used to collect data regarding participants' age, gender, and educational levels. Participants were not paid for taking part in the study and could opt-out from the study at any time during the eight-week program.

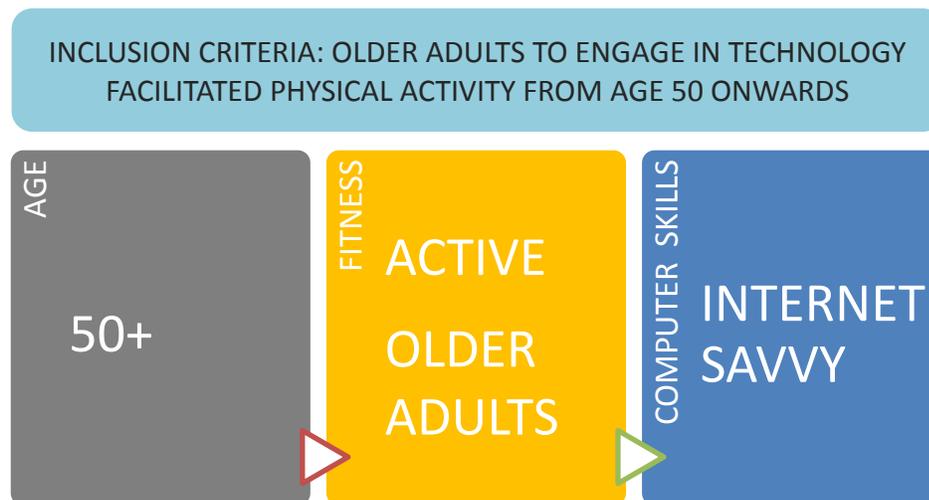


Figure 33: Inclusion Criteria

The descriptive statistics of the participants is shown in Table 22.

¹⁶ <http://www.health.gov/dietaryguidelines/dga2005/healthieryou/html/chapter4.html>

Descriptive Statistics						
Please input your Group Number	N	Minimum	Maximum	Mean	Std. Deviation	Variance
1	10	51	72	60.50	6.556	42.987
Valid N (list wise)	10					
2	10	51	73	63.10	8.056	64.901
Valid N (list wise)	10					
3	10	59	80	68.70	6.676	44.567
Valid N (list wise)	10					

Table 22: Participant age (Group 1, 2, 3)

8.3.3 Procedure

Experimental Group 1: Spirit50 (Gamified Application)

The initial and weekly meetings with participants from this group was carried out in the Live Lab¹⁷, a modern and technologically advanced mobile usability lab located at the Humber College of Technology and Advanced Learning. The experimental setup comprised of a dual screen mode display set up to allow participants to watch the application near their position and a bigger screen that mirrored the contents on the first screen for a bigger picture of the application. Video recording of participants' movements and voice was done using a Samsung webcam mounted on the table. This experimental setup is shown in Figure 34. The tracking of the mouse movements during weekly experimental sessions was also done using the Morae Recorder¹⁸ for

¹⁷ <https://mediastudies.humber.ca/researchlabs/live-labs/usabilitylab.html>

¹⁸ <https://www.techsmith.com/>

future analysis. While the lab had individual testing booths, an open space area in the lab was used to allow for free movement of the participant to do the exercises when prompted by the application.

All participants assigned to Group 1 were invited individually to the usability lab and provided with a login and password for Spirit50.com. They were allowed to choose their *long-term goals*, barriers to doing PA exercises and answer questions regarding their current health situations. These selections enabled the application to identify a low, medium or high intensity exercise routine for an eight-week period and offer *specific goals* that they would have considered to work on. In addition to other specific goals generated by the application, the application also provided a common specific goal (i.e. “Get up and down off the floor with ease”) for all

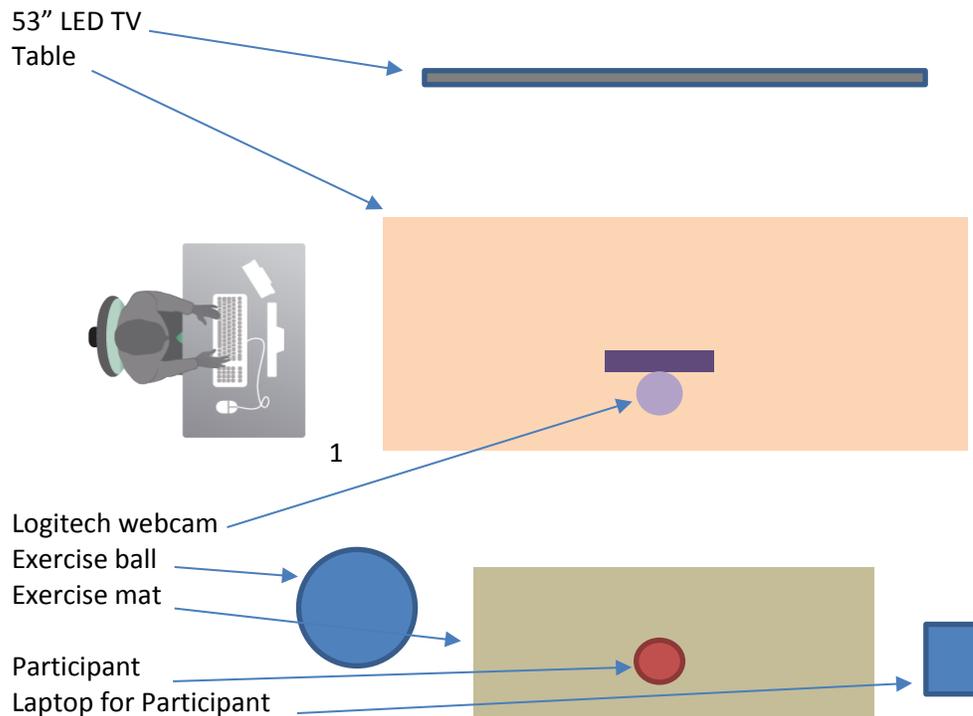


Image Credit for 1: <http://www.posturite.co.uk/media//workstation-setup/workstation-birds-eye.gif>

Figure 34: Experimental Setup

participants. In order to establish a common ground for comparison, all participants in this group were directed to select this specific goal - “Get up and down off the floor with ease”. This provided the participants with an eight-week fitness program tailored for this *specific goal*. The

participants then proceeded to use the application and cycle through the exercise routines as per the instructions provided on the screen. They were asked to use a talk-aloud method to enable recording of their thoughts, feelings and expressions while using the app.



Figure 35: Live Lab (image credit- Humber College)

Once each participant had completed all aspects of the exercise routines, they were provided a paper format of the combined questionnaire with the above scales and were interviewed after the session. All participants were encouraged to login to Spirit50 from home or work to review and follow through on the daily routines planned by the Spirit50 application. Each participant was allocated a scheduled time to meet up every week for testing the exercise routines as they progressed through the program. Post experimental session interviews were conducted each week for the eight-week period.

Experimental Group 2: Pedometer (Non-Gamified)

All participants in this group were provided with a standard clip-on pedometer and asked to continue their physical activities as normal. Participants were provided the questionnaire and interviewed in-person once on a weekly basis or at times electronically via an online format.

Group 3: Control

Participants were asked to go about their normal activities and were provided with a printed format of the questionnaire once each week for the eight-week period. Interviews for this group were conducted via phone, in-person or, Skype interviews. Participants who were unable to meet in-person were provided a link to the survey questionnaire on a weekly basis with a session number, participant ID and a group number. They were asked to provide answers to the interview questions in a long-form answer box provided at the end of the online questionnaire.

8.3.4 Interview Protocol

The interviews were semi-structured and were geared towards understanding their experiences when participating in PA for the week. It was focussed on eliciting answers related motivation to do PA, triggers facilitating PA, barriers, accomplishment and setting up of goals for PA. The questions, in no specific order, were as follows:

1. What was your *motivation* to do the physical activities or exercises this week?
 - 1.1. Were there any triggers that helped you be motivated to do these this week?
2. With regards to physical activity, how do you *decide on setting up goals* to help you do PA or exercises?
3. Were there any accomplishments or *feeling of accomplishment* this week (completion of a task is also an accomplishment)?
4. With regards to PA, were there any *fears or barriers* that you faced this week?
5. Were there any *rewards* (tangible or intangible) that you received or felt/received this week?
6. What kinds of *tracking* information or feedback would you have liked to receive?

8.3.5 Data Collection

Data was gathered in the form of qualitative information from responses to interview questions, and quantitative information provided by answers to the scales questionnaire on motivation.

8.3.6 Participant Demographics

All participants qualified to participate in the eight-week study through the PAR-Q instrument. The IPAQ instrument helped to identify the current baseline intensity levels of participants based on metabolic equivalent tasks (MET) recorded by participants' during the past seven days prior to the start of the eight-week study. Essentially the MET score of an activity is multiplied by the

minutes of the performed activity and is expressed in multiples of the resting metabolic rate (IPAQ-Group, 2005). The MET scores from long form questionnaire established PA levels of participants over the past seven days across four domains: work, active transportation, domestic and garden (yard work), and leisure time. Table 23 indicates details of participant information from the three groups.

Participant Demographics			
	Gamified (N=10)	Non- Gamified (N=10)	Control (N=10)
Age	Mean = 60.5; SD = 6.87	Mean = 63.1; SD = 8.44	Mean = 68.8; SD = 6.66
Gender	F= 4; M=6	F= 3; M=7	F= 3; M=7
MET minutes/week	Mean=4235.4; SD= 870.5	Mean=4785.8; SD= 1103.4	Mean=5521.9; SD= 2348.5

Table 23: Participant Demographics - Experimental Study

The IPAQ quantifies MET scores that relate to populations activity levels and is categorized as low, moderate (at least 600 MET-minutes/week) and high (physical activity of at least 3000 MET-minutes/week) (Hagstromer et al., 2006; IPAQ-Group, 2005). Table 23 indicates that the PA levels of participants in all the three groups to be categorized in the high PA levels of participation, also qualifying them as *active lifestyles*.

8.4 Thematic Analysis

Thematic analysis (TA) is one of the most common qualitative analytic method which involves the identification of themes and patterns within the data (Alhojailan & Ibrahim, 2012; Boyatzis, 1998). While qualitative data analysis is interpretive in nature, TA provides a structured method for analysis through six stages which are: 1) familiarizing yourself with the data, 1) generating the initial codes, 3) searching for themes, 4) reviewing the themes, 5) defining and naming the themes, and 6) producing the report (Braun & Clarke, 2006). In TA a “*theme*” describes “*bulk of the data*” and is used as an attribute elements or and descriptor representing the key ideas in a specific sentence or groups of sentences (Alhojailan & Ibrahim, 2012; Vaismoradi, Jones, Turunen, & Snelgrove, 2016). Themes essentially represent the essence of the participants experiences within the context of the research investigation (Vaismoradi et al., 2016). An

inductive approach represents the development of themes as emergent from the data leading to broader generalizations and theory development (Alhojailan & Ibrahim, 2012; Boyatzis, 1998; Braun & Clarke, 2006). A deductive or ‘top down’ approach represents fitting the data to an existing theoretical framework or guideline (Alhojailan & Ibrahim, 2012; Boyatzis, 1998). Additionally, a combined technique of inductive and deductive thematic analysis uses the data-driven inductive approach to define emergent themes and a deductive a priori template of codes/research questions to formulate categorizations (Boyatzis, 1998; Fereday & Muir-Cochrane, 2006b). This combined method (Fereday & Muir-Cochrane, 2006b) helped to relate the data to the six research questions asked of the participants in this experimental study while providing the flexibility of themes to emerge from the data inductively.

While many explanations of themes and definitions exist (Alhojailan & Ibrahim, 2012; Clarke & Braun, 2013; Vaismoradi et al., 2016), the following definition of themes (Table 24) has been adapted from Fereday et al. (2006) to frame the development of the codebook (Fereday & Muir-Cochrane, 2006b). This codebook was used to code 20% of the data to establish inter-rater reliability and code the remaining data (Fereday & Muir-Cochrane, 2006b; Greg. Guest, MacQueen, & Namey, 2012; Vaismoradi et al., 2016).

Term	Theme Label	Definition	Moderator	Description	Example
Explanation	A name, word or a phrase that represents the “bulk of the data” relating to participants experiences	The definition of what the theme concerns	Perceived impact (Tingleff, Bradley, Gildberg, Munksgaard, & Hounsgaard, 2017)	A description of how to know when the theme occurs.	If necessary provide examples to help with the operationalization of the theme.

Table 24: Definitions of Terms used in the Codebook. Adapted from (Boyatzis, 1998; Fereday & Muir-Cochrane, 2006b)

8.4.1 Data Analysis – Interviews

In all, there were 100 audio recordings of interviews of participants from the three groups. Each recording spanned an average of 15 minutes. In addition, answers to interview questions were provided in written format and through the online data entry format or via emails. The audio recordings were transcribed to textual format using Transcribe^{<https://transcribe.wreally.com/>}, an online transcription tool. Once transcribed, the answers were collated under the six interview questions listed under the Interview Protocol section (Section 8.3.4). This resulted in six Excel spreadsheets under the following interview questions: motivation to participate in PA, setting up goals to participate in PA, fears or barriers to participate in PA, accomplishments, rewards and tracking. Thematic analysis was used to identify themes emergent from the data.

8.4.2 Codebook Design

8.4.2.1 Themes for Physical Activity

This section represents the codebook for the six research questions (Section 8.3.4) that were asked in the experimental study. To allow for better clarity and simplicity of usage of the codebook, the themes relevant to each question related to older adults' PA is represented in a separate table. Using the inductive and deductive method proposed by Fereday et al. (Fereday & Muir-Cochrane, 2006b), while themes within the question categories emerged inductively, the following six questions were used as deductive generalizable categories:

1. Motivation for PA
2. Setting up goals in PA
3. Accomplishments in PA
4. Fears and barriers for PA
5. Rewards and PA
6. Tracking of PA

8.4.2.2 Operationalization

Transcripts were coded line-by-line to break up the data into its component parts or properties (Charmaz, 2006; Corbin & Strauss, 2015). Open coding was done on each sentence of the transcripts to identify the interpreted meaning of the interview data into phrases that represented each sentence by the participant (Corbin & Strauss, 2015). Characteristics of the meaning of these codes were also notated in the Excel file identifying the properties of the code. These codes

essentially explicated actions to meanings (Charmaz, 2006; Gallicano, 2013) of participant responses. The above process was done for all participant responses for each of the six questions. These properties and open coding for the six questions are indicated in the following tables (Table 25 - Table 30) (Braun & Clarke, 2006; Clarke & Braun, 2013; Fereday & Muir-Cochrane, 2006b; Greg. Guest et al., 2012; Tingleff et al., 2017).

The next step was to see if there existed any relationship between these open codes, which would then be aggregated into a higher category or themes. This process is identified as thematic coding (Alhojailan & Ibrahim, 2012; Boyatzis, 1998) which is the process of relating higher level categories to sub categories (Charmaz, 2006; Corbin & Strauss, 2015). Thematic coding was done for all the six interview question responses. The interview responses were then sorted based on the group number and themes to gather interview responses and to evolve characteristics of the categories.

The following rules were used to identify themes for the six question categories.

1. Each emergent theme was specific to either of the six question categories.
2. For each list of participant responses specific to the above question category, themes were allocated to the responses.
3. Once themes were assigned to all participant responses from one question category, the next set of transcripts consisting of participant responses for the next category was coded similarly
4. While themes in different question categories seemed similar, care was taken not to assign the themes from one category to participant responses from another category.

Motivation for PA

Theme label	Definition	Moderator (perceived impact)	Description of concepts and examples
Accomplishing a goal	Accomplishing challenges with ease; realizing a big improvement; desiring to do something; multitasking to meet challenges; inspiring	Positive	Not gasping for breath; trying out high or low intensity activity, doing anything/some activity; success in activity, completing chores, doing ambitious activities; fostering

	situations; comparing results; exciting and feeling energetic; keeping commitments; persevering to put effort; understanding the benefits of PA; training for immediate goals		an attitude change, instilling curiosity, hitting targets, increased ambition, having success, increased simplicity; doing all routines, doing few sessions, doing new routines, continuing with old routines, completing intensity types, preparing for an activity
Aging well	Accepting of increasing age; crossing an age milestone; preventing old age; overcoming challenges with aging	Positive	Being conscious; getting older; feel good about aging; better fitness while aging
Challenged by activity	Challenging goals for higher intensities; desiring to complete PA; overcoming boring gym routines; desiring to do PA despite hectic activities; persevering on a routine; desiring to be challenged; trying to make a significant push; combining endurance, flexibility and strengthening routines; desiring to do more; accomplishing more; wanting to feel the burn; improving endurance, flexibility and strengthening; obsessing about workout'; preferring to be challenged; exploring new routines; stepping up the game; falling short of expectations	Positive/negative	Strong mentality to do more PA; tiredness infusing more PA; overcoming hectic schedule encouraging to do PA; being out of breath is an impetus to do more; celebration of success; hoping for PA challenges; complement all domains of exercise with PA; pushing oneself; resolution to do PA; combining high and low intensities; overcoming past failures; overcoming unattainable tasks; result of effort; gauging capability and ability; increasing intensity levels; overcoming tiredness; understanding capabilities; need for variety
Easy access to resources	Benefitting from good trainers; cheaper online programs; committing to a PT; challenging situations at the gym; stimulating confidence from coaches in person or virtually; relying on expert recommendations; being able to PA anywhere and anytime; flexibility of schedule, space and equipment;	Positive	Dedication to schedule; distasteful gym environments; pushing by coaches; convenience; exciting interface and equipment; distractions at home; flexibility of choice and schedule; doing routine tasks; worrying about tasks; greater resolve of schedule
Enjoying outdoors	Enjoying the weather; desiring solitariness; organizing messy outdoors; doing PA away	Positive	Excitement to be outdoors, improvement of garden, inspiring and interesting yard work, inclination to do more,

	from home; preferring outdoorsy activities; doing outdoor activities subconsciously leading to fitness; preferring strenuous work; combining outdoor and indoor activities		overriding tiredness to do yard work, improvement in scenery, encouragement due to visual delight, presentable outdoors, overcoming challenges to clean up the garden, combining PA tasks and yard work.
Experiences	Feeling good; improving energy levels; increasing excitement levels; inspiration to do more; internalizing the need to do more; overcoming laziness	Positive/Negative	Be energetic; inspired feeling; overcoming inertia to do nothing; work against gravity; meet goals
Fear of being unhealthy	Self-awareness; recognizing deficiencies; fearing inability; empathizing with family member; realizing need for being healthy	Negative	Getting concerned about health; awareness of deficiencies; desire to be active; concerned about mortality; concerned about balance; overweight; poor health; sedentariness; inability to walk; poor health
Focussing on appearance	Accepting of body shape; maintaining waist size; desiring weight loss; improving physical shape; toning of muscles; obsessing about weight; exercising for slimming	Positive/Negative	Lose weight; distasteful body shape; “waist” management; tempered body; excitement, feeling of weight loss; tangible results of slimming, belt size, weight, waist size; satisfaction; irritability of shape (body)
Focussing on motivational affordances	Allure of accomplishments; quantifying PA; inspiring achievements; remembering to do PA; tracking feedback	Positive	Badges, points, stars, medals, slogans, clapping, images, challenges, rewards, tracking; bell, text, note, ring; feedback, weights, progress, effort, posture; virtual trainer
For a healthy lifestyle	Accepting of body challenges; being active; working towards activities; understanding the benefits; understanding limitations; preferring an active lifestyle; overcoming sedentariness; improving health goals; optimizing mind and body	Positive	Lack of flexibility; outdoor and indoor activities; endurance, mobility, flexibility, good health, relaxation, training muscles, energy levels, live longer, optimal health; poor health, getting cramped with non-activity; short bursts of activity many times to overcome sedentariness
Freedom of usage	Persisting to doing PA correctly; Accepting of doing PA; prioritizing schedule, space and activity; adapting easily; freedom of affordances	Positive	Understanding steps and timing; scheduling possibilities; flexibility of doing PA anywhere; simplicity of instructions; variety, sound, voice command, interface; timers
Fun and recreation	Creating time to do PA; committing to variety; intergenerational activity;	Positive	Making time voluntarily to play; getting it done; swimming with grandchildren;

	combining locations and equipment; enjoying outdoors; enjoying different types of PA; improving one's perspective; enjoying spontaneity		walking, gardening, swimming; different locations are not problematic; not a chore, activity for fun, variety of game types; sudden bursts of activity
Influenced by the app	Using it anywhere anytime; appreciation of ability; challenging routines; correcting posture; comparing with peers; influencing to do more; complimenting endurance and strengthening; committing to a schedule; following through on work done; providing companionship; reviewing effort and progress; proving ability of doing PA; easing remembrance of routines; inspiring technology	Positive	Flexibility of doing the exercise routines; being able to do the PA; simplicity; combine with gym, endurance and strengthening; eight-week routine, reminder to do daily short bursts, compare with spouse, companion (virtual trainer), routine challenges; easy recall, simplicity
Inspirational influencers	Inspiring to do PA; performing at a high level; understanding desire to excel; remembering past laurels; playing team sports	Positive	Experts, knowledge, family members, good teachers, coaches, doctors, online experts, online training, younger individuals, physiotherapists.
Limitations of resources	Incurring expenses; training by PT; changing routines; failing at the gym; intimidating gym environment; continuing with same routines; scheduling challenges; planning leading to failure; dieting is a challenge; self-monitoring of challenges	Negative	Expensive; reluctance; discouragement; difficulty in waking up; inability to keep up; partners to play; food cravings; limited freedom at the gym; lack of interest in fixed routines
Mental wellbeing	Changing attitude; stimulating physical and mental wellbeing; reliving freedom from exercise equipment; disappointing intensities; feeling unable to do more; tempering one's mind; being true to oneself; reaching a cruising state; overcoming laziness; overcoming low energy levels; feeling of satisfaction; relying on values; persevering to continue; relaxing virtues; reflecting on the self	Positive/Negative	Desire to improve; lower stress; intensity levels; discouragement; fearful of boredom, inability, failure, commitment issues; overcoming guilt; achieving a state; lethargy, inertia, anxiety, venting; praise, feeling better, pleasure; past glory, laurels, achievements, habits; combination of simple routines; overcoming a lull feeling, resolve to do more, inspirational; confidence from past

Routine/Lifestyle	Accommodating routines; committing to a schedule; challenging daily routines; forming a habit; working with routines; balancing routines;	Positive	Mixing new and old routines; schedule flexibility; regular activities; changes in routines; past training; self-regulation, self-monitoring; consistency of schedule; high and low intensities
Social connections	Encouraging interactions; making social connections; comparing ability with others; seeking group connections	Positive	Group activities, spouse, friends, team, presence of others, familiar people; younger persons; overcoming tiredness; encouragement; companionship; online connections; walking, bike riding, golfing, hockey, gym; sharing, satisfaction; distracting relatives
Spontaneous and subconscious activity	Exciting spontaneous activities; preferring to do household activities	Positive	Excitement about on the spur of the moment; activities leading to exercises;
Treatment for a health issue	Overcoming health challenges; worrying about taking pills; desiring weight loss; improving health condition; being self-aware of challenges	Positive/Negative	Bad knees, obesity, shape, posture, back problems, hip condition, quintuplet bypass, scoliosis; stiff and immobile, unbalanced and frozen, allergic reactions, passing away of friends and family, fatigue, dehydration, blood pressure.

Table 25: Codebook - Motivation for PA

Setting up of Goals for PA

Theme label	Definition	Moderator (perceived impact)	Description of concepts and examples
Combining exercise types	Combining endurance, flexibility and strengthening; combining low, medium and high intensity; combining household and outdoorsy activities	Positive	Sports and exercise routines; high and low intensity; indoor and outdoor activities
Committing time for activity	Booking time for routines; committing time to others; enrolling in a program	Positive	Flexibility; schedule; availability
Enjoying combination of activities	Participating in competitions; combining indoor and outdoor activities; working towards a scheduled routine; encouraging results increased PA	Positive	Walkathons, swimming, sporting activity, exercise routines, household activity, outdoorsy activities; scheduled tasks; encouragement due to success
Focussing on goals	Working towards results; curious for progression; improving confidence and	Positive	Daily goals; weight loss; strength in arms; endurance; overcome sitting; balance and

	interest; preparing for competitive activity		flexibility; improving posture; overcoming lethargy/laziness; upper body strength
Focussing on appearance	Improving waist size; slimming down	Positive	“Waist” management; body shape
Focussing on motivational affordances	Getting stars and points; increasing intensity due to results; increasing step count; inspiring activity by penalties; checking off activities; progressing towards goals	Positive	Stars and points; results and intensity; penalties or negative points; pecking order, list; progression
Improving health outlook	Realizing potential to do more; being active and mobile; resolving to do more; overcoming lethargy;	Positive	Benefits; reliving past laurels; fit and mobility outlook; interests; overcome laziness
Increasing challenges progressively	Building up step by step; increasing targets; improving fitness levels; pushing hard for more achievements	Positive	Weights, muscle groups, daily step targets, stamina, time taken, goals; higher intensities; switching intensities easily; improvement; hitting targets; making it interesting
Self-regulating routines	Programming schedule for activities; working towards healthy lifestyle; maintaining interest through variety	Positive	Be fit and healthy, being flexible, exiting the home; limited time availability; personal routines; virtual coach; failure leading to PA; watching videos; planning; deadline; perfecting; consistent correctness of routines; being accustomed, being familiar
Social interaction	Engaging in social activity types; comparing progression;	Positive	Walkathons, socialize, group exercises, common goal, comparing within group, spouse;
Spontaneous and subconscious activity	Feeling spontaneity of action; Working on household activities leading to PA	Positive	Not being forced, subconscious activity

Table 26: Codebook - Setting up of Goals for PA

Accomplishments in PA

Theme label	Definition	Moderator (perceived impact)	Description of concepts and examples
Adding new challenges	Increasing challenges to existing routines; replacing existing routines with new ones; being able to combine types of activities	Positive	Increasing flexibility; increasing frequency, endurance, flexibility, strengthening exercises; indoor and outdoor activities
Influencing activity through app	Realizing deficiencies through app; being able to do better; feeling energetic	Positive	arm strength, ability, improving flexibility, app helped identify deficiencies, more energy

Completing difficult challenges	Being able to do vigorous activities, completing difficult tasks	Positive	Increased intensity, completed hectic activity, outdoor and indoor activities; yard work, swimming, hockey exercise routines, app routines
Feeling of mental satisfaction	Feeling happy and satisfied; feeling better; wanting to do more	Positive	Tiredness feels good; felt like pushing to do more; feeling content; trying harder; satisfaction of completion
Feeling the burn	Doing a good workout, changing attitude	Positive	Having done something, burn in the muscles, attitude
Feeling validated for efforts	Being energetic, feeling happy; feeling of increased energy	Positive	No complaints, commitment forces effort, felt good
Improving body conditioning	Getting results; relaxing of body; improving awareness about body	Positive	Tighter muscles, toning, maintaining weight, loosing of body; flexibility routines; posture improvement; upper body strength; better breathing
Improving confidence	Reaching targets; sense of achievement; giving it the best shot	Positive	Increase points target; confidence of abilities; wall push-ups; feeling like being able to do more; becoming easier to do;
Improving health condition	Overcoming health situations	Positive	Making pain go away, sleep better, relieve sore back issues, hip movement, posture improvement
Improving ability	Increasing targets or goals	Positive	Higher weights, loosens body, able to do it on one's own; feeling good to do higher intensities, able to do upper body workout; becoming easier; wall push-ups, challenging routines, able to improve posture, relaxed pace; able to touch toes; faster timing; do for longer time; feeling of missing out on PA;
Increasing independence	Being able to do more easily; doing it anywhere and anytime; flexible combination of indoor and outdoor activities;	Positive	PA becoming easier, faster and longer durations, changing routines easily
Inspiring motivational affordances	Reassuring effort by rewards; achieving targets	Positive	Praise, compliments, progress bar, rewards, stars, points; completion of tasks; progression through challenges; redeeming points; visual representation of efforts, step targets, distance walked
Inspiring performance	Feeling like doing better each time; trying more; reaching greater targets; curious to see end result;	Positive	Better, happy, doing more; pushing oneself; age appropriate movements; reaching peak

	feeling like continuing; overcoming laziness		ability; complimented on performance by others
Progressing through activities	Completing tasks; accomplishing a lot; combining intensities and types of exercises	Positive	Reminders; adding challenges; doing routines; happy with progression information;
Seeking external resources	Seeking recommendations	Positive	Fitness consultant; yoga instructors, recommendations from doctors, physiotherapists
Social interaction	Making social connections	Positive	Working in groups; working well with people

Table 27: Codebook - Accomplishments in PA

Fears and Barriers

Theme	Definition	Moderator (perceived impact)	Description of concepts and examples
Challenging health conditions	Fearing changes in health; aging issues; balance issues	Negative	Biopsy, cancer check, obesity, shoulder injury, knee challenges, ligament tears, posture, gait check, shingles scare, pain
Fearing inability	Fearing not being mobile; inability to do things on one's own; avoidance rather than doing; maintain good health;	Negative	Inability, immobile, fear of injury, challenges of good health,
Fearing appearance issues	Changing shape; defining body features	Negative	Broad waist; flabby belly, bad posture
Having psychological challenges	Lacking mental and physical drive; feeling weak; feeling failure; lacking commitment	Negative	Low energy levels; low inclination; psychologically weak; tiredness; lack of accomplishment; commitment issues; invasion of privacy; making excuses not to do PA
Limiting resources	Limiting spatial challenges; temporal challenges; equipment challenges	Negative	Gym environment, home environment; time; finances; technology usage;
Fearing lack of performance	Being aggressive; being obsessive about details;	Negative	Overestimating and falling short; preparing for a future activity; pain
Fearing social interaction	Fearing group activities; Connecting with people	Negative	Too pushy, different goals between peers, needing to be alone

Table 28: Codebook - Fears and Barriers

Rewards in PA

Theme	Definition	Moderator (perceived impact)	Description of concepts and examples
Completing an activity	Being like a game; feeling of relief; reaching daily targets;	Positive	Daily routines, tasks, exercises, step targets; victory in completion; points target, step

			target, correct and consistent completion;
Having freedom of usage	Discovering new abilities; having flexibility of usage	Positive	Curiosity; Anywhere anytime, while boiling eggs, in pyjamas, did not feel like it
Having intangible rewards	Achieving targets; feeling of doing well; complimenting situations	Positive	Reaching 30k/day, sincere praise, feeling important, more energy, good; not wanting outside gratification; gaining knowledge; getting easier, satisfaction of completion; short-term, long term rewards;
Having tangible rewards	Getting something out of activity	Positive	Unchanged belt buckle position, different sceneries, weight loss, looking better; wine, beer, chocolates; smell the flowers; lower caloric intake (food);
Feeling of mental satisfaction	Experiencing different feelings	Positive	Feeling good, better, less tired, visual improvement; easy remembering of activities; minimizing pain;
Having self-awareness	Understanding deficiencies;	Positive	Lack of arm strength, lack of good posture, unable to do any push-ups; weakness in areas
Having sense of accomplishment	Recognising achievements	Positive	Increased intensity routines; amazing feeling of completion; feeling the burn, burn in legs; not winded when climbing stairs; feeling relaxed
Improving confidence	Feeling of doing more; being able to do different type of exercises; trying out different things;	Positive	Trying strength training; flexibility exercises; combinations
Influencing characteristics of the app/pedometer	Noticing benefits; being a companion	Positive	Easy remembering of routines; noticing the aspect of feeling stronger; bragging rights (wall push-ups); virtual companion; really helping with understanding deficiencies and possible improvements
Improving health condition	Being more flexible; having better awareness; wanting to do better	Positive	Conscious of posture; improving posture; not being out of breath; increased flexibility
Inspiring motivational affordances	Feeling rewarded	Positive	Progression, points, stars, badges, progress bar, goals, levels; praise, compliments; check-points, scratching of a list; task completion, having rules, redeeming points, monthly comparisons; overcoming discouragement; validation of efforts
Seeing results of efforts	Tracking indicates results of efforts;	Positive	Burning calories, reaching points, steps target, meeting;

			reassurance to be on the plan (program); felt like purchasing exercise equipment with metrics; activity leads to exercise subconsciously
Social activity	Working with people	Positive	Transgenerational activity; competing, influence with spouse; working for and with loved ones
Uninspiring motivational affordances	Stressing over rewards	Positive	Not competitive today, too stressful, obsessing over food, points is bad,

Table 29: Codebook - Rewards in PA

Tracking in PA

Theme	Definition	Moderator (perceived impact)	Description of concepts and examples
Challenging tracking issues	Feeling anxiety due to numbers, challenged with technology; punishing oneself with numbers	Negative	Invasive technology, slaves to technology, not concerned with numbers; low phone usage; inputting data is painful
Indicating completion status	Feedback for completion; monitoring feeling	Positive	Checkmark, clapping, energy level; praise, compliments
Improving body form	Tracking posture; helping to correct form; improving confidence	Positive	Like a mirror, form checker, waist size, synchronizing body movements and required movements
Indicating motivational affordances	Indicating achievements; personalizing messages information	Positive	Time duration, checking off a list; leaderboards, progression, comparison with others, effort meter; points redemption; personalizing dialogue and text; improvement in numbers is promising
Making social connections	Comparing progress or lack of; making connections; learning from others	Positive	Giving confidence; you are not alone; learning, sharing
Needing feedback	Types of feedback; checking posture; attaining goals; prompting activity; progressing through the week and through activity	Positive/Negative	Voice driven, music, bell, small talk, ease of use and companionship, reminders, notes regarding progress, correcting posture; inactivity; virtual coach
Measuring physical activity	Changing body activity; tracking progression; comparing with others	Positive	Weight, steps, calorie burn, calorie intake, distance, HR, time taken, diet, effort (can this be tracked?), progression; achievement levels, points earned, score, comparison

Table 30: Codebook - Tracking in PA

Detailed themes, definitions and properties specific to each group are indicated in the appendix (section 13.9).

8.4.2.3 Evaluating the Codebook

In order to review the operationalization of the codebook against participants' responses, as a pilot, another researcher (second coder) coded 1% of the data from each of the six question categories. Comparison of the coding between the two raters indicated percentage agreement, Cohen's Kappa coefficient (Cantor & Lee, 1996) and Krippendorff's Alpha (Swert, 2012) to be above 80% indicating good reliability (Fereday & Muir-Cochrane, 2006b; Greg; Guest, MacQueen, & Namey, 2012; Seaborn, Pennefather, & Fels, 2016). Based on this review a few explanations were added to the "descriptions" column of the codebook. Subsequent to this, 20% of the data were coded by the second coder. Details of the total number of participant responses, data used in pilot coding and for reliability analysis is shown in Table 31.

Question Categories	Responses	20% data	Data used for pilot coding 1%	Actual data used for pilot coding	Data used for 20% coding 20%	Actual data used for 20% coding 20%
Motivation for PA	981	196.8	10	10	197	199
Setting up goals for PA	274	54.6	3	10	55	59
Accomplishments in PA	488	97.4	5	10	97	97
Fears or barriers in PA	105	20.8	1	10	21	26
Rewards in PA	417	83.2	4	10	83	86
Tracking in PA	378	75.4	4	10	75	79
Total responses	2643	528.2				546

Table 31: Data used for Thematic Analysis

Details of the reliability analysis is indicated in Section 8.4.2.4.

8.4.2.4 Reliability

Reliability in thematic analysis is also a measure of predictability of the findings (Greg; Guest et al., 2012; Miles, Huberman, & Saldana, 2014) and is determined using inter-coder reliability (Mouter, Noordegraaf, & Noordegraaf, 2012). Seaborn et al. (2016) used a random sample of

20% of the data to test reliability of the themes (Seaborn et al., 2016). Additionally, random sampling of 20% of the data was also used for reliability testing in prior studies (Cantor & Lee, 1996; Greg; Guest et al., 2012; Lumsden, Edwards, Lawrence, Coyle, & Munafò, 2016; Mekler et al., 2014; Swert, 2012). Therefore, in order to establish reliability of the emergent themes for each question category, a random selection of 20% of the data for each question category was coded for themes by a second coder (Cantor & Lee, 1996; Fels, Udo, Diamond, & Diamond, 2006; Seaborn et al., 2016; Swert, 2012; Vaismoradi et al., 2016). Additionally, care was taken to ensure that this dataset included responses for each theme and moderator. Krippendorff's Alpha (k-alpha)(Krippendorff, 2004; Swert, 2012) and Cohen's Kappa (Cantor & Lee, 1996) was used as a measure of inter-rater reliability, where the k-alpha values above 0.8 and kappa values above 0.66 were considered to be good metrics for ratings by two coders respectively (Greg; Guest et al., 2012; G. W. Ryan & Bernard, 2000). Comparison of the percentage agreement, kappa and k-alpha for each of the question category is shown in Table 32.

Question Categories	Total transcribed responses	20% random sample	% Agreement	Cohen's Kappa	k-Alpha	N Agreements	N Disagreements	N Cases	N Decisions
Motivation for PA	981	199	93.0	0.9	0.9	185	14	199	398
Setting up of Goals	274	59	84.7	0.8	0.8	50	9	59	118
Accomplishment of Goals	488	97	91.2	0.9	0.9	89	8	97	194
Fears and Barriers	105	26	88.5	0.9	0.9	23	3	26	52
Rewards in PA	417	86	91.9	0.9	0.9	79	7	86	172
Tracking in PA	378	79	94.9	0.9	0.9	75	4	79	158
Total responses	2643	546							

Table 32: Thematic Analysis - Reliability Testing

8.5 Quantitative Analysis

At the onset, there were three groups of participants, 10 participants in each group, and eight weeks of sessions leading to 240 instances of data collection points. SPSS was used to analyse the data for normality and subsequent significance testing. Data from the PNSE and IMI scales were tested for normality within each group using the Kolmogorov-Smirnov (K-S) and the Shapiro-Wilk tests. These are indicated in Table 33 and Table 34.

		Tests of Normality (PNSE)					
		Kolmogorov-Smirnov ^a			Shapiro-Wilk		
Number	Dimensions	Statistic	df	Sig.	Statistic	df	Sig.
1	Perceived Competence	.233	80	.000	.696	80	.000
	Perceived Autonomy	.271	80	.000	.643	80	.000
	Perceived Relatedness	.195	80	.000	.790	80	.000
2	Perceived Competence	.158	80	.000	.879	80	.000
	Perceived Autonomy	.227	80	.000	.827	80	.000
	Perceived Relatedness	.247	80	.000	.865	80	.000
3	Perceived Competence	.151	80	.000	.952	80	.004
	Perceived Autonomy	.234	80	.000	.788	80	.000
	Perceived Relatedness	.142	80	.000	.946	80	.002

a. Lilliefors Significance Correction

Table 33: Tests of Normality (PNSE)

The dimensions of perceived competence, perceived autonomy and perceived relatedness, $D(80)$, $p < 0.05$, were significantly non-normal.

		Tests of Normality (IMI)					
		Kolmogorov-Smirnov ^a			Shapiro-Wilk		
Number	Dimensions	Statistic	df	Sig.	Statistic	df	Sig.
1	Interest/Enjoyment	.174	80	.000	.867	80	.000
	Perceived Competence	.172	80	.000	.804	80	.000
	Effort/Importance	.138	80	.001	.926	80	.000
	Pressure/Tension	.182	80	.000	.918	80	.000
	Perceived Choice	.103	80	.037	.959	80	.012
	Value/Usefulness	.310	80	.000	.641	80	.000
	Relatedness	.098	80	.054	.945	80	.002
2	Interest/Enjoyment	.273	80	.000	.847	80	.000
	Perceived Competence	.233	80	.000	.889	80	.000
	Effort/Importance	.167	80	.000	.908	80	.000
	Pressure/Tension	.138	80	.001	.947	80	.002
	Perceived Choice	.146	80	.000	.928	80	.000
	Value/Usefulness	.265	80	.000	.802	80	.000
	Relatedness	.296	80	.000	.799	80	.000
3	Interest/Enjoyment	.111	80	.017	.945	80	.002
	Perceived Competence	.099	80	.051	.972	80	.002
	Effort/Importance	.173	80	.000	.952	80	.004

Pressure/Tension	.262	80	.000	.661	80	.000
Perceived Choice	.135	80	.001	.914	80	.000
Value/Usefulness	.172	80	.000	.879	80	.000
Relatedness	.079	80	.200*	.966	80	.032

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 34: Tests of Normality (IMI)

The Shapiro-Wilk statistic yields exact significance and is more accurate than the K-S test (Field, 2013). All dimensions in the three groups, $D(80)$, $p < 0.05$, were significantly non-normal.

Descriptive statistics for both scales are shown in Table 35 and Table 36.

Descriptive Statistics (PNSE)

Number	Dimensions	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
							25th	50th (Median)	75th
1	Perceived Competence	80	5.19	1.105	1	6	4.67	5.67	6.00
	Perceived Autonomy	80	5.45	.905	2	6	5.17	5.83	6.00
	Perceived Relatedness	80	4.72	1.491	1	6	4.33	5.17	6.00
2	Perceived Competence	80	4.90	.896	3	6	4.50	5.00	5.50
	Perceived Autonomy	80	5.30	.650	4	6	5.00	5.00	6.00
	Perceived Relatedness	80	3.83	1.613	1	6	2.00	4.67	5.00
3	Perceived Competence	80	4.70	.653	3	6	4.21	4.83	5.17
	Perceived Autonomy	80	5.59	.522	4	6	5.33	5.83	6.00
	Perceived Relatedness	80	4.43	.999	2	6	3.71	4.17	5.29

Table 35: Descriptive Statistics (PNSE)

Descriptive Statistics (IMI)									
Number	Dimensions	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
							25th	50th (Median)	75th
1	Interest/Enjoyment	80	5.71	1.061	3	7	5.33	6.00	6.33
	Perceived Competence	80	5.88	1.080	2	7	5.50	6.00	6.67
	Effort/Importance	80	4.40	1.055	2	6	3.60	4.60	5.20
	Pressure/Tension	80	3.70	.634	2	5	3.40	3.60	4.00
	Perceived Choice	80	5.21	1.093	3	7	4.32	5.29	6.14
	Value/Usefulness	80	6.06	1.498	1	7	6.00	6.50	7.00
	Relatedness	80	4.68	1.076	3	7	3.78	4.75	5.72
2	Interest/Enjoyment	80	5.56	.969	3	7	5.17	5.83	6.29
	Perceived Competence	80	5.56	.857	4	7	5.33	5.67	6.13
	Effort/Importance	80	4.17	.964	2	6	3.40	4.10	5.20
	Pressure/Tension	80	3.81	.642	2	5	3.40	3.80	4.40
	Perceived Choice	80	5.64	1.011	3	7	4.61	5.86	6.43
	Value/Usefulness	80	6.13	.876	4	7	6.00	6.25	7.00
	Relatedness	80	4.17	1.128	3	7	3.25	3.38	5.22
3	Interest/Enjoyment	80	5.16	1.016	4	7	4.21	5.00	6.00
	Perceived Competence	80	5.16	.771	4	7	4.83	5.17	5.67
	Effort/Importance	80	4.05	.804	2	6	3.60	3.80	4.60
	Pressure/Tension	80	3.60	.500	2	6	3.40	3.40	3.60
	Perceived Choice	80	5.79	1.043	3	7	5.00	6.07	6.71
	Value/Usefulness	80	5.90	1.075	3	7	5.25	6.00	7.00
	Relatedness	80	4.41	.654	3	6	4.00	4.50	5.00

Table 36: Descriptive Statistics (IMI)

8.6 Findings from Analysis

8.6.1 Findings from Thematic Analysis

Exploring the relationships between open codes led to evolving themes (axial codes) for the six interview questions: motivation, setting up goals, feeling of accomplishment, fears and barriers, rewards, and tracking of physical activity. Comparison of the axial codes emerging for the three groups are shown in the following Tables (Table 37 - Table 42):

8.6.1.1 Motivation for PA

Group 1		Group 2		Group 3	
Themes	N	Themes	N	Themes	N
Accomplishing a goal	107	Accomplishing a goal	14	Accomplishing a goal	9
Aging well	9	Aging well	2		
Challenged by activity	124	Challenged by activity	15	Challenged by activity	4
Easy access to resources	27				
Enjoying outdoors	38	Enjoying outdoors	12	Enjoy outdoors	7
Experiences	15	Experiences	7		
Fear of being unhealthy	10	Fear of being unhealthy	4	Fear of being unhealthy	2
Focussing on appearance	30	Focussing on appearance	13		
Focussing on motivational affordances	36	Focussing on motivational affordances	15	Focussing on Motivational affordances	3
For a healthy lifestyle	72	For a healthy lifestyle	20	For a healthy lifestyle	5
Freedom of usage	23				
Fun and recreation	22	Fun and recreation	2	Fun and recreation	5
Influenced by the app	42	Influenced by the app (pedometer)	1		
Inspirational influencers	12				
Limitations of resources	26	Limitations of resources	2		
Mental wellbeing	48	Mental wellbeing	12	Mental wellbeing	2
Routine/Lifestyle	57	Routine/Lifestyle	3	Routine/Lifestyle	8
Social connections	53	Social connections	5	Social connections	2
Spontaneous and subconscious activity	11	Spontaneous and subconscious activity	2	Spontaneous and subconscious activity	1

Group 1		Group 2		Group 3	
Treatment for a health issue	29	Treatment for a health issue	9	Treatment for health issue	7
	791		138		55

Table 37: Themes for Motivation for PA

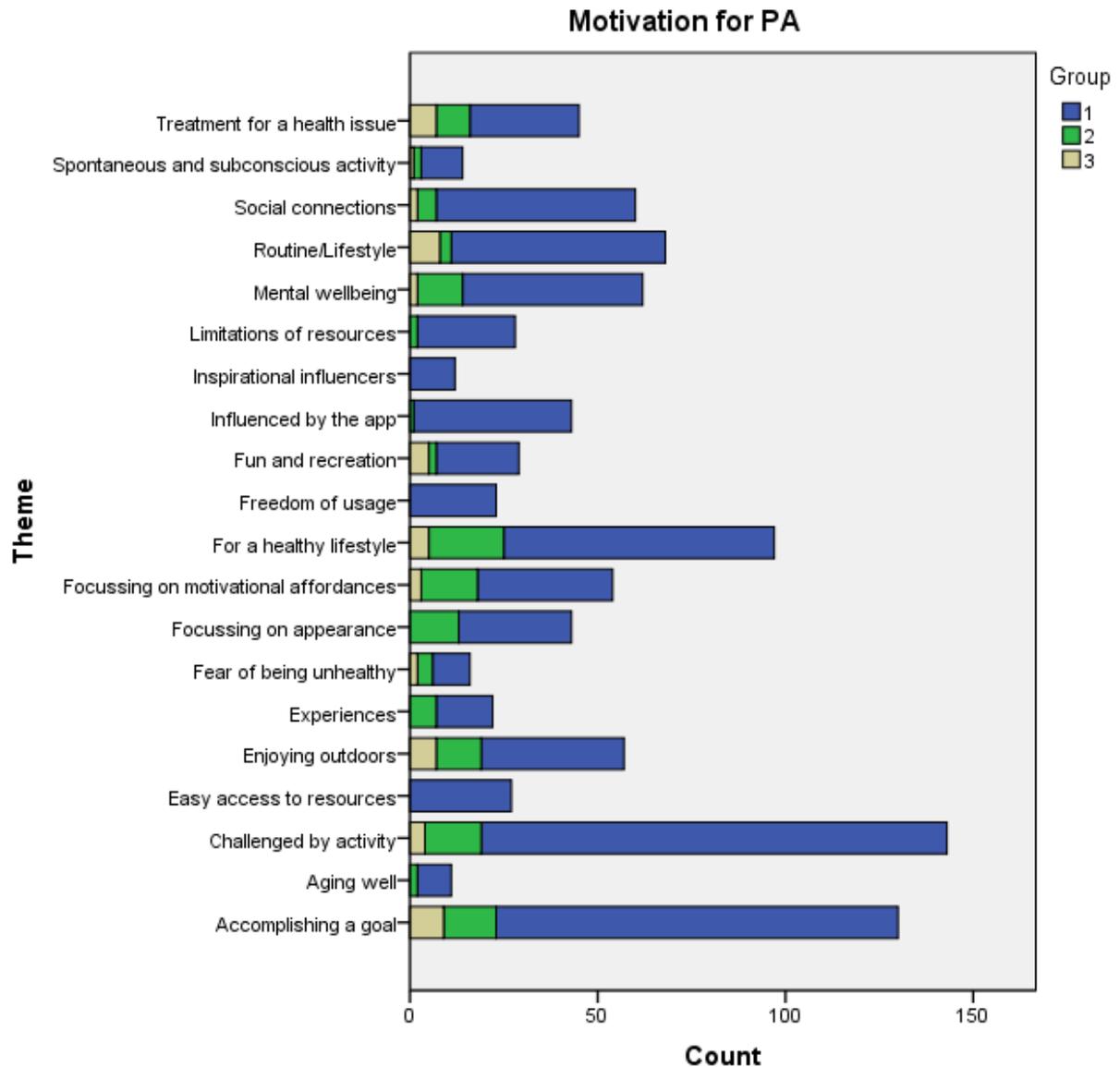


Figure 36: Stacked histogram for Motivation for PA

8.6.1.2 Setting up Goals for PA

Group 1		Group 2		Group 3	
Themes	N	Themes	N	Themes	N
Combining exercise types	27	Combining exercise types	2	Combining exercise types	3
Committing time for activity	8				
Enjoying combination of activities	28			Enjoying combination of activities	1
Focussing on appearance	6				
Focussing on goals	35	Focussing on goals	12	Focussing on goals	3
Focussing on motivational affordances	13	Focussing on motivational affordances	7	Focussing on motivational affordances	5
Improving health outlook	9	Improving health outlook	5	Improving health outlook	4
Increasing challenges progressively	26	Increasing challenges progressively	9	Increasing challenges progressively	1
Self-regulating routines	48	Self-regulating routines	5	Self-regulating routines	1
Social interaction	8	Social interaction	4	Social interaction	1
Spontaneous and subconscious activity	2				
	210		44		19

Table 38: Themes for Setting up Goals for PA

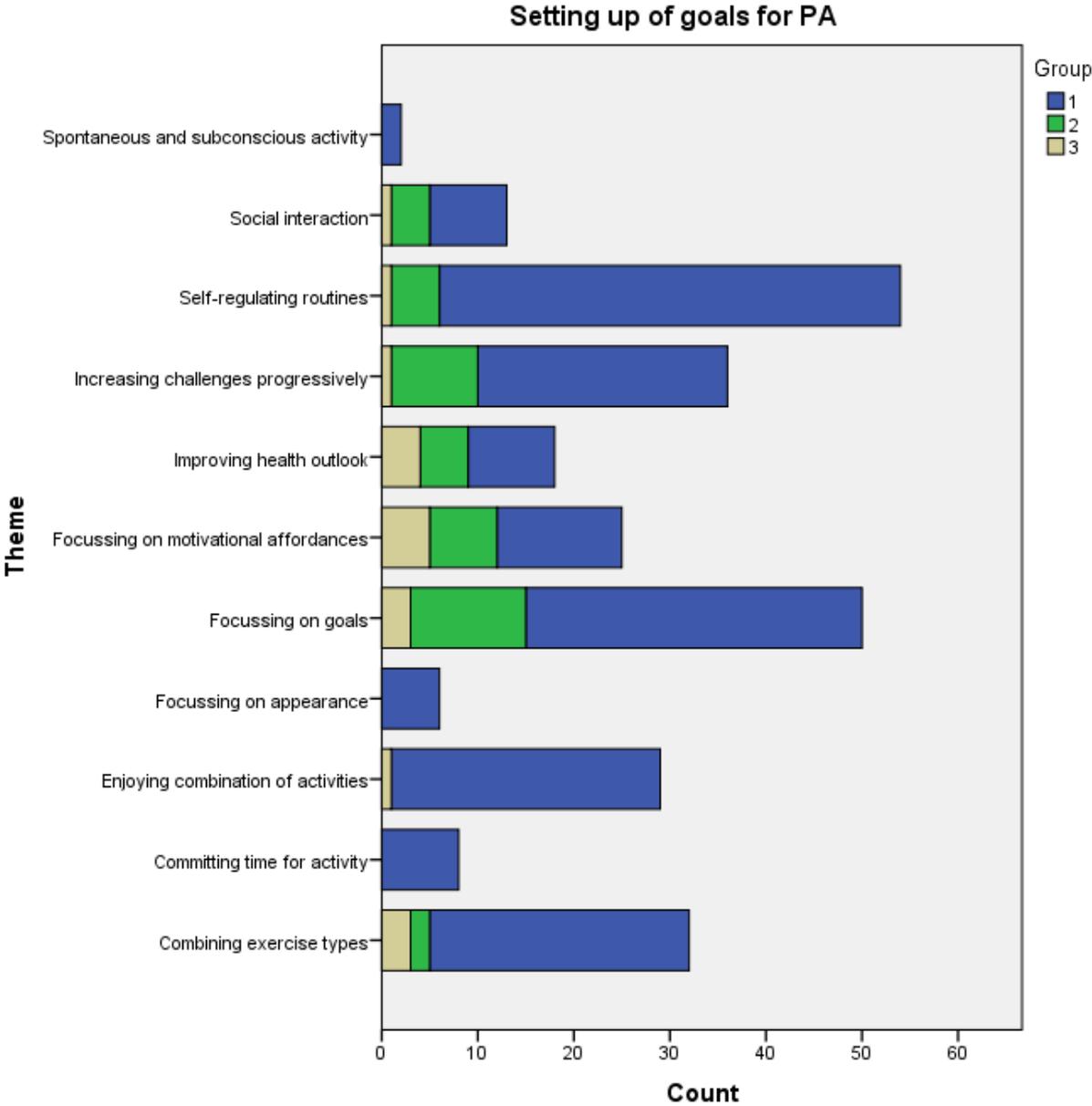


Figure 37: Stacked histogram for Setting up Goals for PA

8.6.1.3 Feeling of Accomplishment in PA

Group 1		Group 2		Group 3	
Themes	N	Themes	N	Themes	N
Adding new challenges	19	Adding new challenges	30	Adding new challenges	9
Completing difficult challenges	19	Completing difficult challenges	29	Completing difficult challenges	16
Feeling of mental satisfaction	10	Feeling of mental satisfaction	13	Feeling of mental satisfaction	12
Feeling the burn	5	Feeling the burn	2		
Feeling validated for efforts	9	Feeling validated for efforts	2	Feeling validated for efforts	1
Improving ability	55			Improving ability	6
Improving body conditioning	15	Improving body conditioning	6	Improving body conditioning	5
Improving confidence	8	Improving confidence	8	Improving confidence	8
Improving health condition	9	Improving health condition	1	Improving health condition	7
Increasing independence	8				
Influencing activity through app	8				
Inspiring motivational affordances	18	Inspiring motivational affordances	17		
Inspiring performance	19	Inspiring performance	6		
Progressing through activities	46	Progressing through activities	27	Progressing through activities	18
Seeking external resources	5	Seeking external resources	2		
Social interaction	6	Social interaction	1	Social interaction	2
	259		144		84

Table 39: Themes for Feeling of Accomplishment

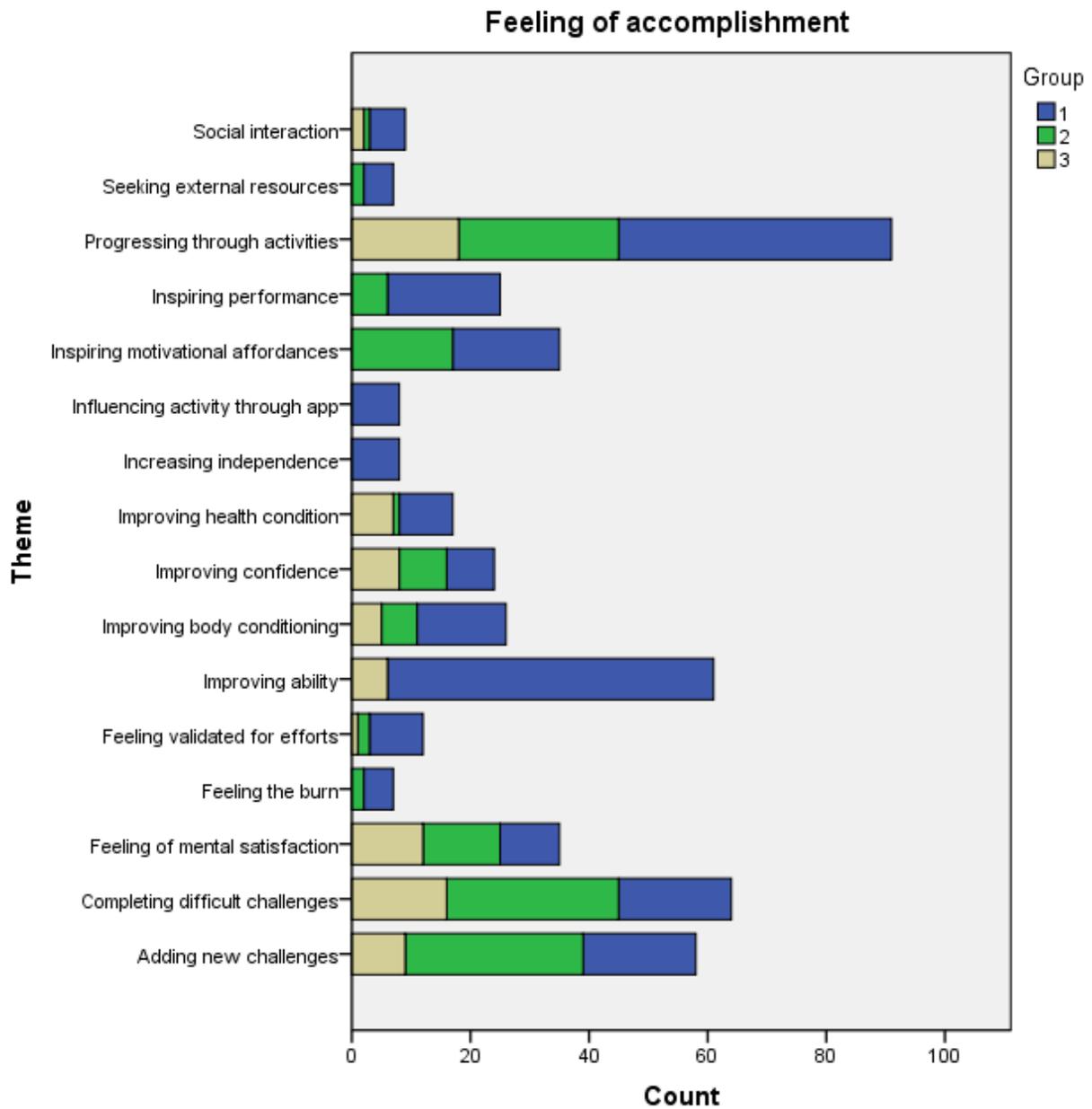


Figure 38: Stacked histogram for Feeling of Accomplishment

8.6.1.4 Feeling of Fears and Barriers

Group 1		Group 2		Group 3	
Themes	N	Themes	N	Themes	
Challenging health conditions	15	Challenging health conditions	8	Challenging health conditions	7
Fearing appearance issues	5				
Fearing inability	8	Fearing inability	13	Fearing inability	4
Fearing lack of performance	6	Fearing lack of performance	2	Fearing lack of performance	3
Fearing social interaction	2				
Having psychological challenges	8	Having psychological challenges	1	Having psychological challenges	1
Limiting resources	10	Limiting resources	8	Limiting resources	3
	54		32		18

Table 40: Themes for Fears and Barriers

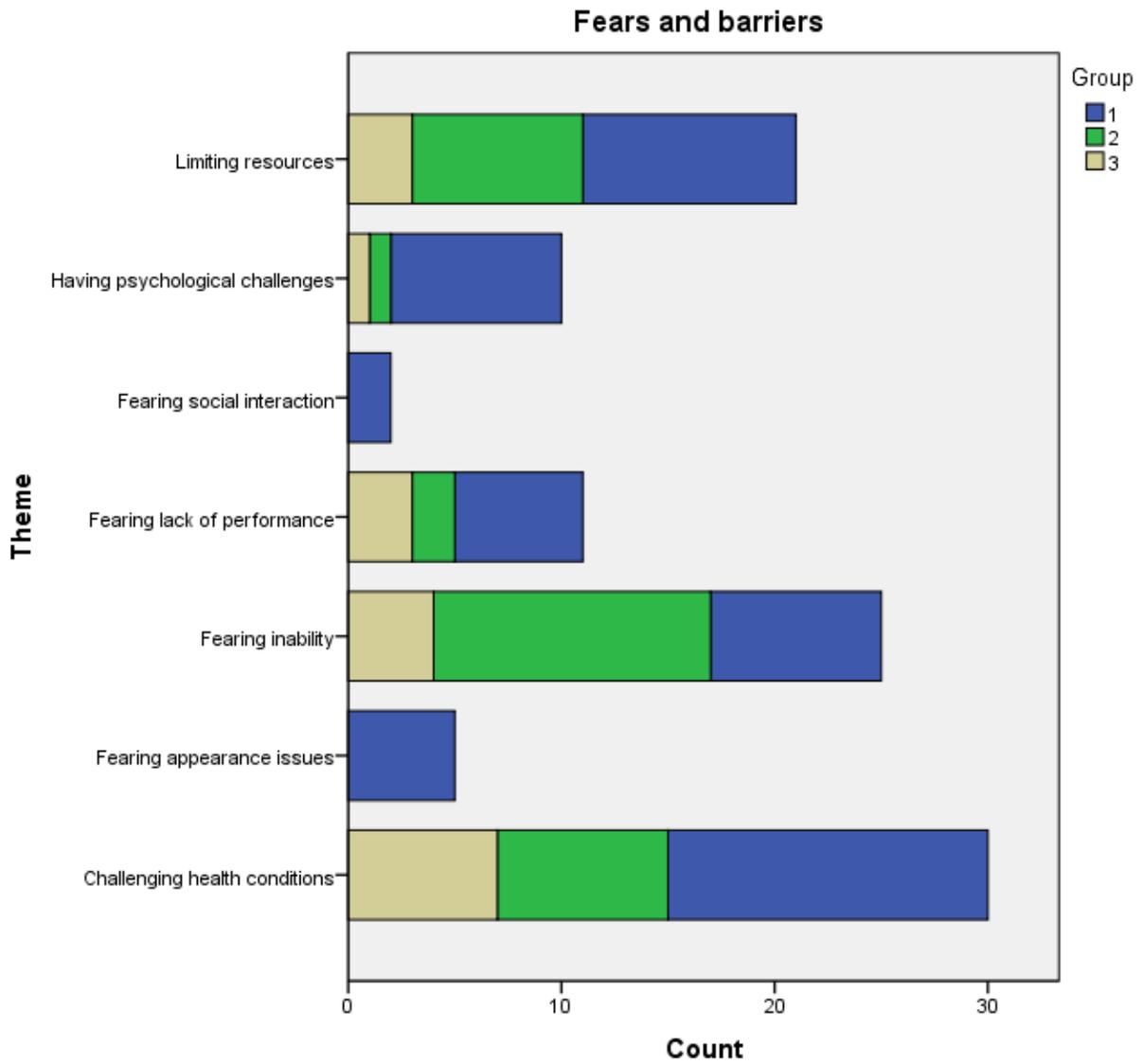


Figure 39: Stacked histogram for Fears and Barriers

8.6.1.5 Feeling of Rewards in PA

Group 1		Group 2		Group 3	
Themes	N	Themes	N	Themes	N
Completing an activity	22	Completing an activity	18	Completing an activity	10
Feeling of mental satisfaction	14	Feeling of mental satisfaction	27	Feeling of mental satisfaction	22

Group 1		Group 2		Group 3	
Having freedom of usage	7	Having freedom of usage	1		
Having intangible rewards	19	Having intangible rewards	1	Having intangible rewards	2
Having self-awareness	5	Having self-awareness	6		
Having sense of accomplishment	11	Having sense of accomplishment	14	Having sense of accomplishment	9
Having tangible rewards	33	Having tangible rewards	43	Having tangible rewards	22
Improving confidence	7	Improving confidence	4		
Improving health condition	8	Improving health condition	4	Improving health condition	14
Influencing characteristics of the app	5				
Inspiring motivational affordances	53	Inspiring motivational affordances	2	Inspiring motivational affordances	1
Seeing results of efforts	14	Seeing results of efforts	2	Seeing results of efforts	1
Social activity	4	Social activity	1	Social activity	3
Uninspiring motivational affordances	6	Uninspiring motivational affordances	3		
	208		124		84

Table 41: Themes for Rewards in PA

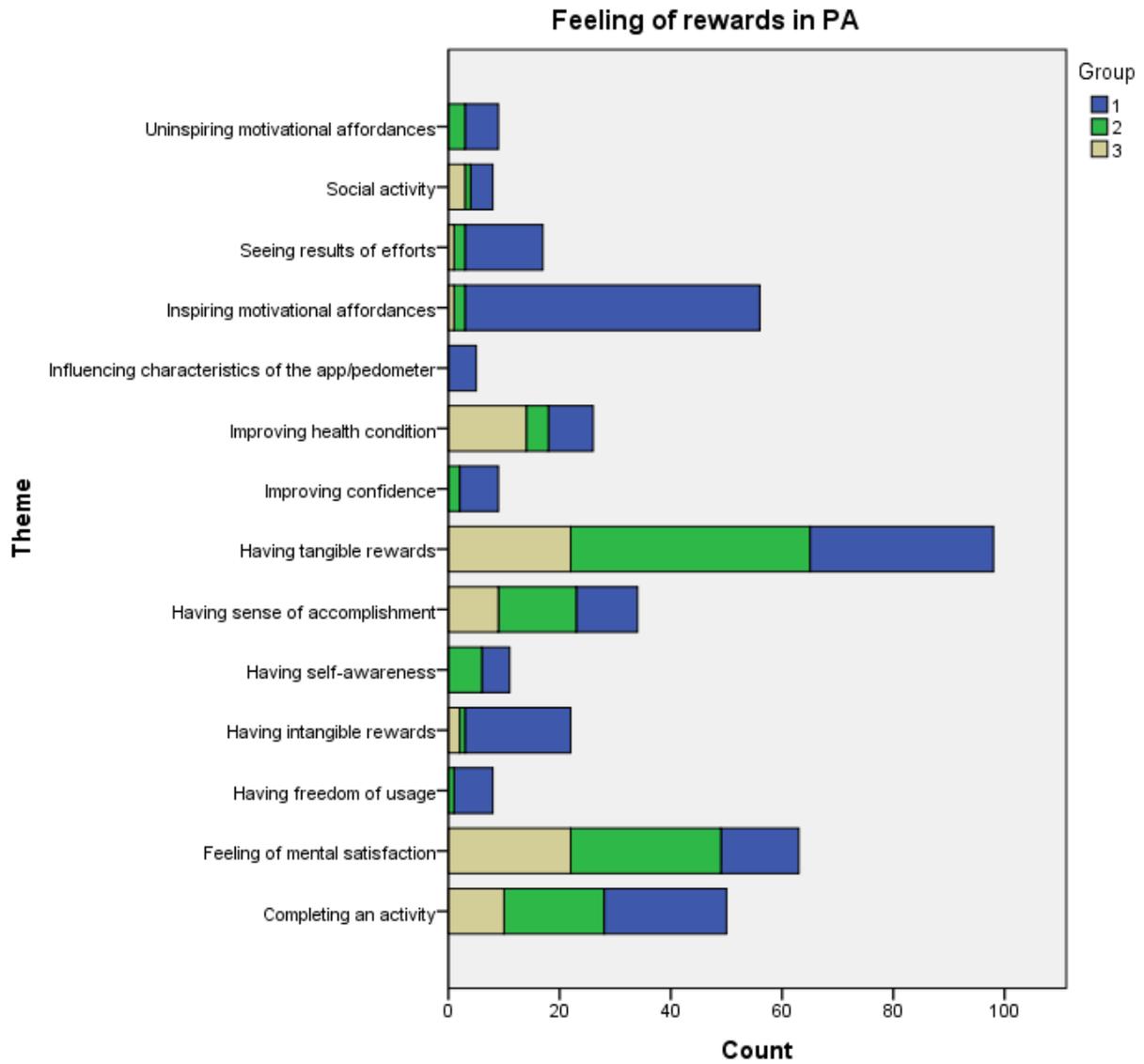


Figure 40: Stacked histogram for Rewards in PA

8.6.1.6 Tracking of PA

Group 1		Group 2		Group 3	
Themes	N	Themes	N	Themes	N
Challenging tracking issues	19	Challenging tracking issues	18	Challenging tracking issues	12
Improving body form	19	Improving body form	6	Improving body form	2

Group 1		Group 2		Group 3	
Indicating completion status	7	Indicating completion status	3	Indicating completion status	2
Indicating motivational affordances	21	Indicating motivational affordances	3	Indicating motivational affordances	2
Making social connections	4	Making social connections	1		
Measuring physical activity	69	Measuring physical activity	100	Measuring physical activity	61
Needing feedback	25	Needing feedback	5	Needing feedback	3
	164		133		80

Table 42: Themes for Tracking of PA

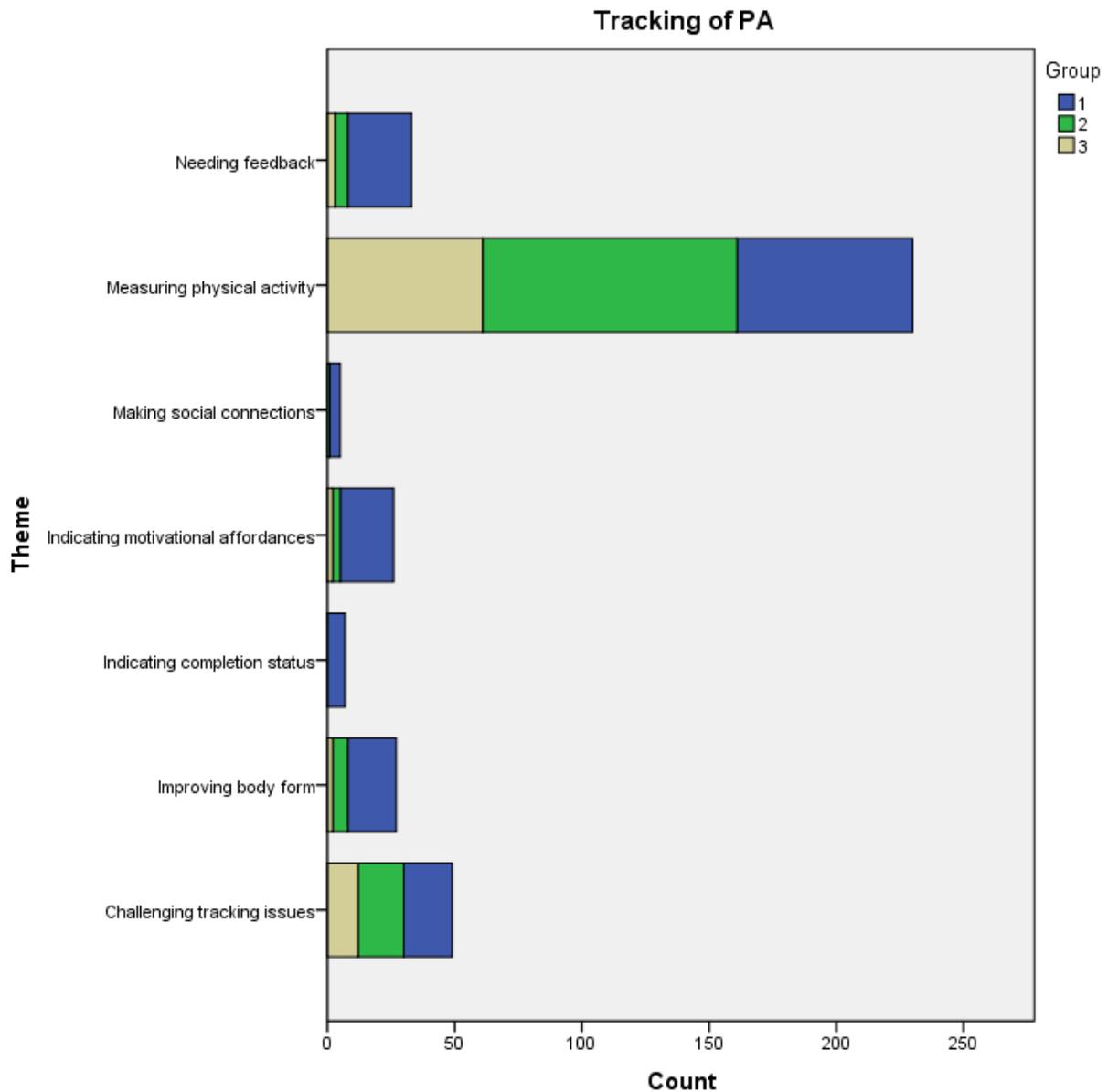


Figure 41: Stacked histogram for Tracking of PA

8.6.2 Findings from Quantitative Analysis

The Psychological Need Satisfaction in Exercise (PNSE) scale (Wilson et al., 2006) measures perceived need satisfaction and is based on the view that psychological needs are a motivating force in achieving certain goals (R. M. Ryan et al., 1997). This scale was used to measure participants' motivation for PA and exercise routines on a weekly basis. The Intrinsic Motivation Inventory (IMI) was used to evaluate the participants' subjective experiences, and

engagement related to the specific intervention associated with each group. The Rate of Perceived Exertion (RPE) scored participants feeling of exertion, weekly, on a scale of 0 (no exertion at all) to 10 (highest exertion).

Answers from participants for these two scales, collected over an eight-week period were compared between the three groups (Group 1 = gamified, Group 2 = non-gamified, Group 3 = control). This study had 10 participants in each group with a total of 80 responses in each group.

8.6.2.1 Overall Tests for Repeated Measures within Groups

Friedman's ANOVA was used to test for differences within groups in a repeated measures design where each participant within a group did the exercise routines on a weekly basis and reported their experiences using the PNSE and the IMI scales. Detailed statistical tables are shown in Appendix 13.10.1

Friedman's ANOVA (PNSE)

For the **PNSE scale**, the analyses are shown in Table 43 and Table 122.

Ranks (Friedman's ANOVA)		
	Please input your Group Number	Mean Rank
1	Perceived Competence	1.96
	Perceived Autonomy	2.45
	Perceived Relatedness	1.59
2	Perceived Competence	2.07
	Perceived Autonomy	2.56
	Perceived Relatedness	1.38
3	Perceived Competence	1.67
	Perceived Autonomy	2.79
	Perceived Relatedness	1.54

Table 43: Output from Friedman's ANOVA (PNSE)

The three dimensions of the PNSE scale: perceived competence, perceived autonomy and perceived relatedness indicated significance ($p < 0.05$) depending on which type of intervention. There was a statistically significant difference in Group 1 ($\chi^2(2) = 44.5, p < 0.05$), Group 2 ($\chi^2(2) = 66.6, p < 0.05$) and Group 3 ($\chi^2(2) = 80.3, p < 0.05$). This indicated that the

interventions helped to significantly change the dependent variables over the course of eight-weeks. Follow-up tests were carried out and are explained in Section 8.6.2.3.

Friedman's ANOVA (IMI)

For the **IMI scale**, the data analyses are shown in Table 44 and Table 123.

Ranks (Friedman's ANOVA)		
	Please input your Group Number	Mean Rank
1	Interest/Enjoyment	4.99
	Perceived Competence	5.19
	Effort/Importance	2.66
	Pressure/Tension	1.87
	Perceived Choice	4.33
	Value/Usefulness	5.79
	Relatedness	3.17
2	Interest/Enjoyment	4.82
	Perceived Competence	4.58
	Effort/Importance	2.18
	Pressure/Tension	2.32
	Perceived Choice	5.34
	Value/Usefulness	6.30
	Relatedness	2.46
3	Interest/Enjoyment	4.46
	Perceived Competence	4.71
	Effort/Importance	2.40
	Pressure/Tension	1.61
	Perceived Choice	5.72
	Value/Usefulness	5.84
	Relatedness	3.26

Table 44: Output from Friedman's ANOVA (IMI)

The dimensions of the IMI scale indicated significance ($p < 0.05$) depending on which type of intervention. There was a statistically significant difference in Group 1 ($\chi^2(2) = 222.0, p < 0.05$), Group 2 ($\chi^2(2) = 286.4, p < 0.05$) and Group 3 ($\chi^2(2) = 274.6, p < 0.05$). This further indicated that the interventions helped to significantly change the dependent variables over the course of eight-weeks. Follow-up tests were carried out and are explained in Section 8.6.2.3.

8.6.2.2 Overall Tests between Groups

Data were ordinal, non-normal and were binned into the three groups using the grouping variable and tested using the Kruskal-Wallis test for differences. Detailed statistical tables are shown in Appendix 13.10.2

Based on the Kruskal-Wallis test for the PNSE scale (Table 124), motivation was significantly affected by the interventions for the dimensions related to perceived competence [$H(2) = 28.77$, $p < 0.5$], perceived autonomy [$H(2) = 8.76$, $p < 0.5$], and perceived relatedness [$H(2) = 17.60$, $p < 0.5$] (Table 124).

Jonckheere-Terpstra test (Table 125) also revealed a significant trend between the groups in the perceived competence ($J = 6491$, $z = -5.33$, $r = -.34$) and the perceived relatedness dimension ($J = 8064$, $z = -2.63$, $r = -.17$). Since the groups were coded as 1 = gamified, 2 = non-gamified and 3 = control, and the negative value of the z statistic indicated a trend of descending medians as the coding variable got bigger, which indicated a rising trend toward the gamified group.

Based on the Kruskal-Wallis test for the IMI scale (Table 126), significance was indicated in specific dimensions (all effects are reported at $p < 0.5$). Engagement was significantly affected by the interventions: interest/engagement ($H(2) = 12.45$), perceived competence ($H(2) = 39.65$), effort/importance ($H(2) = 6.21$), pressure/tension ($H(2) = 12.56$), perceived choice ($H(2) = 12.5$), value/usefulness ($H(2) = 6.43$), relatedness ($H(2) = 10.42$).

Jonckheere-Terpstra's test for the IMI scale (Table 127) revealed a significant trend in the data: since the groups were coded as 1 = gamified, 2 = non-gamified and 3 = control, and the negative value of the z statistic indicated a trend of descending medians as the coding variable got bigger, which indicated a rising trend toward the gamified group. Significant trend in the data was seen in the following dimensions: Interest/Enjoyment: $J = 7602$, $z = -3.42$, $r = -.22$; Perceived Competence: $J = 5824$, $z = -6.46$, $r = -.41$; Effort/Importance: $J = 8272$, $z = -2.28$, $r = -.14$; Perceived Choice: $J = 11616$, $z = 3.45$, $r = .22$; Value/Usefulness: $J = 8116$, $z = -2.60$, $r = -.16$

Kruskal-Wallis Test (RPE)

The comparison for RPE showed significant exertion between the groups $H(2) = 24.3, p < .05$. The Jonckheere-Terpstra's test revealed a significant trend in the data: $J = 12277, z = 4.618, r = .30$. The positive z statistic indicates a rising trend of medians as the coding variable increased, indicating that the participants in the gamified group (Group 1) felt lower exertion compared to the participants from the control group (Group 3).

8.6.2.3 Follow-up Tests

Mann-Whitney test were used to follow up the findings by comparing Group 1 (gamified) and 2 (non-gamified), Group 1 and 3 (control), and Group 2 and 3. Bonferroni correction was applied and all effects are reported at 0.0167 ($p < 0.05/3$) level of significance. Detailed statistical tables are shown in Appendix 13.10.3.

Mann-Whitney Test (PNSE)

Exercise need satisfaction was compared between groups and the results are indicated below:

Gamified (Group1) – Non-gamified (Group 2):

When comparing the mean ranks between the groups, Group 1 (gamified) indicated higher perceived competence and perceived relatedness in comparison to Group 2 (Table 128).

Tests indicated that perceived competence ($U = 2341, r = -0.23$) and perceived relatedness ($U = 2125, r = -0.29$) were significant at this level and ranked higher in Group 1 (Table 129).

Gamified (Group1) – Control (Group 3):

When comparing the mean ranks between the groups, Group 1 (gamified) indicated higher perceived competence and perceived relatedness in comparison to Group 3 (Table 130).

Tests indicated that perceived competence ($U = 1629, r = -0.42$) and perceived relatedness ($U = 2125, r = -0.26$) were significant at this level and ranked higher in Group 1 (Table 131).

Non-Gamified (Group2) – Control (Group 3):

When comparing the mean ranks between the groups, Group 2 (non-gamified) indicated higher perceived competence in comparison to Group 3 (Table 132). However, while Group 3 indicated significance in the perceived autonomy dimension ($p < 0.0167$), the mean ranks for perceived autonomy and perceived relatedness were also higher for Group 3.

Tests indicated that perceived autonomy ($U = 2712, r = -0.13$) were significant at this level and ranked higher in Group 3 (Table 133).

Mann Whitney Test (IMI)

Experience and engagement in the intervention routines were compared between groups as a follow-up test. Results are indicated as follows:

Gamified (Group1) – Non-Gamified (Group 2)

While the mean ranks of perceived competence and perceived relatedness were higher in Group 1 (gamified), the rankings in perceived choice were higher in Group 2 (non-gamified) than in Group 1 (Table 134). All effects reported at $p < 0.0167$, perceived competence ($U = 2312, r = -0.24$), perceived choice ($U = 2489, r = -0.19$) and relatedness ($U = 2345, r = -0.23$) were significantly different between the groups (Table 135).

Gamified (Group1) – Control (Group 3)

While interest/enjoyment, perceived competence, effort/importance dimensions ranked higher for the non-gamified group, perceived choice was ranked higher in the control group (Table 136). All effects reported at $p < 0.0167$, interest/enjoyment ($U = 2201, r = -0.27$), perceived competence ($U = 1481, r = -0.46$), effort/importance ($U = 2448, r = -0.20$), perceived choice ($U = 5440, r = -0.27$) dimensions indicated a significant difference between groups (Table 137).

Non-Gamified (Group2) – Control (Group 3)

All effects reported at $p < 0.0167$, interest/enjoyment ($U = 2482, r = -0.19$), perceived competence ($U = 2030, r = -0.31$), and pressure/tension ($U = 2139, r = -0.29$) dimensions

showed significant differences between the two groups (Table 139). The above three dimensions also ranked higher in the non-gamified group compared to the control group (Table 138).

8.7 Discussion: Experimental Study

This study was conducted in three synchronous groups of active-adults over 50 years of age. The goal was to examine the influence of motivational affordances through PA technology over an eight-week period. Based on the findings from the qualitative analysis, in addition to the influences of technology, I discuss the themes (axial codes) influencing PA that emerged from the three groups for each of the six interview questions. Details of sample participant responses are indicated in Section 13.8.

8.7.1 Motivation for PA

The comparison of themes shown in Table 37 indicate many intrinsic motivation categories (concepts) emerging from the open coding process. These categories are discussed in relation to the technology characteristics and applicability of these characteristics as gleaned from participants' responses. Sample participant responses are shown in the appendix (Appendix 13.8).

Accomplishing a goal: Participants in Group 1 were motivated by several factors: completing a goal with ease; realizing significant health improvements and being active. They were inspired by in-app progress reports and did outdoor activities to increase their level of PA. Multitasking to do app activities and household chores, and outdoor activities pushed them to continue to do more PA. They felt energized by the routines provided by the app. This, combined with their regular PA activities motivated them to persevere with PA. The app introduced the delineation between immediate goals (specific goals) and long-term goals, which allowed participants to acknowledge the value of doing simple tasks as well as, doing short bursts of exercise routines, of various intensities to help them feel like accomplishing a lot. The app helped participants perceive that achievement of small steps of exercise routines were bigger successes from a feel-good perspective, which was similar to the result from the study about beliefs around PA among older adults in rural Canada (Schmidt, Rempel, Murray, Mchugh, & Vallance, 2016).

In the same vein, Group 2 participants were motivated by factors such as: accomplishing challenges with ease, hitting pedometer targets, doing something active (as in outdoor or fitness activities). Additionally, inspiring situations such as reminiscing about former fitness levels, lack of PA and, increase in pedometer numbers enabled participants to persevere with their effort of doing more PA. Increased awareness of the benefits of PA were also triggers for accomplishing a goal, similar to the results seen in a prior study (Jancey, Clarke, Howat, Maycock, & Lee, 2009).

For Group 3 (control), the motivating factors were: performing tedious outdoor activities and completing challenges with ease were motivations to do PA. Additionally, this group was inspired to allocate more time to outdoor activities because of scheduled morning workouts. This inclination could have been due to increased freedom of choice between many outdoor activities such as walking the dog, playing with grandchildren (P07), swimming (P25), dancing (P27), and participating in aerobic exercises or Tai Chi (P20).

A few examples of participants' responses from the respective groups are shown in the appendix (Appendix 13.8). This indicated that for Group 1 and Group 2, the presence of the app and the pedometer influenced the participants to do more activities while accomplishing a goal.

Aging well: Being conscious and accepting of growing older (P04), working out to age gracefully (P16) and the interest to overcoming age-related challenges (P05) served as motivations for PA in Group 1 and Group 2. This theme was not evident in Group 3.

Challenged by activity: Increasing the intensity of PA routines or exercises, as well as trying to complete hectic and difficult activities, were relevant motivational elements for Group 1. Additionally, being prompted with higher intensity routines, or new exercise routines through the app, provided greater motivation to stay with the app. Combining regular outdoor PA routines like yard work, gardening, or raking with indoor exercise routines helped with sustaining a variety throughout the week. At the same time, personal life challenges hindered PA activity (P04), and the stress of preparing for a future hiking activity (P31) added the stress in the week for doing PA. Overcoming lethargy and laziness by using simple exercises (P10) also helped as a motivating element for this category.

In Group 2, overcoming boredom (P13), and lack of patience in dealing with daily chores (P06) created triggers for going out for walks. The pedometer influenced participants to increase walking distance (P23), increase the types of challenges to their existing routine of walking such as: going up the hills and adding additional hills on the routine trek.

In Group 3, pushing to the point of pain or aches to achieve predetermined challenges, like preparing for a 12-km run (P25), as well as the excitement of participating in a competition (P27) were triggers for being challenged by an activity. Detailed participant responses are shown in the appendix (Appendix 13.8).

Easy access to resources: Challenges with distasteful gym environments, the flexibility to do the app applications anywhere (P10), including in one's own home environment and in one's home attire served as triggers in this category (P31). Additionally, costs played into the acceptability of online programs. While there is a commitment and a sense of obligation towards an in-home physical trainer, the plausibility of a virtual coach through the app was well received.

Participants from Group 2 and Group 3 did not indicate any motivational triggers in this category.

Enjoying outdoors: This category emerged from participants' responses across all the three groups. In Group 1, the preferences for doing the app exercises outside the home environment was desirable due to the potential of too many distractions at home (P11, P31). Physical activity outdoors (e.g. climbing in and out of the boat to empty its gas tank) did help to bring back certain routines learned from the app (P04). There was a general consensus to do outdoor activities such as hiking, walking, bike-riding, playing tennis, or running when the weather was good (P01, P11, P16). These activities also did help participants to reminisce about a few routines practised from the app. This allowed for easy recall of app routines and participants realized its value while working outdoors (P08).

In Group 2, participants were open to enjoy the outdoors (P18, P21) which resulted in more step count on their pedometers, which was similar to a subconscious side-effect of doing an activity. Group 3 participants did not bother much about any tracking their steps while outdoors and spent more time enjoying the weather (P12, P15).

Experiences: Participants from Group 1 were interested in wanting to feel good (P01), improve energy levels, increase excitement levels and have a positive outlook towards fitness (P08). From an app perspective, participants felt like doing the app exercises to feel good about a commitment. They did not consider the app complex (P08, P16), but they believed that it definitely helped with the realization of taking small steps towards a bigger goal (P31).

Feeling good to see the numbers increase (pedometer) after a vigorous activity (P23) and doing something for the sake of doing an activity (P18) were common motivation concepts in Group 2 for the experience category. This theme was not evident in Group 3.

Fear of being unhealthy: In Group 1, working on the simplistic app routines was one way of doing something to be active and allay the fears of being inactive and overcome the fear of getting stale (P01). The participants found the app routines to be simple and doable (P04) and helped them overcome their fears of being unable to do these routines (P11).

In Group 2, one participant had a “sick” feeling due to inactivity and decided to move around and add some steps on the pedometer (P18).

Group 3 participants were mostly concerned about inactivity and their future health which was a motivational trigger for them to be active (P15). Predominantly, the fear of being unhealthy due to inactivity was a prime concept that motivated participants to feel like doing something (P25).

Focussing on appearance: In Group 1, there was a desire to improve their physical appearance by controlling their weight, slim down and overcome obesity (P08). Using the simple exercise routines from the app encouraged the participants to realize the simplicity of being able to do the

app exercises anywhere and anytime (P11, P16, P24). This enabled the app to be used frequently to improve their flexibility and posture. (P04)

Participants from Group 2 added more step-count on their pedometers to shed some weight, slim down for a future trip and have a more toned body (P13). Adding more steps with the intention of “shedding some fat” (P02) with the realization that in summer there are “less clothes to hide behind” (P02, P18). This theme was not evident in Group 3.

Focussing on motivational affordances: In Group 1, participants acknowledged and accepted the motivational affordances as trigger elements to do more PA. These ranged from monitoring or the desire to measure PA as a means of reassurance and validation for effort being done towards PA (P08). These motivational affordances ranged from simple tracking of effort, receiving badges, points and progression information and comparing effort with peers and/or spouses (P11). Participants also offered suggestions to add motivational slogans and inspirational imagery to help establish aspirational goals (P24). While points and stars seemed inconsequential, it was good to earn some (P16) and also push further to earn more points. Initially, the existence of points and stars were not acknowledged, however, as they progressed through the weeks (P11), these elements did get noticed and inspired the desire to reach higher levels within the app. Participants took time to realize that the increase in points and stars corresponded to the completion of daily and weekly exercise routines.

In Group 2, it was noticed that participants walked more than their step-count in the first week to achieve daily step targets (P05). One participant who was unaware of projected daily step targets, and was used to doing less than 1000 steps/day, pushed herself to achieve more than 10K steps by week 3 (P23). Participants also indicated that step-count, time and distance done, were key triggers to do more PA (P21). Additionally, calories and weight loss information also served as triggers to do more PA (P18).

In Group 3, participants mentioned that while they noticed their time investment in PA (P15), they were keen on weight loss as seen on their bathroom scale (P25).

For a healthy lifestyle: Participants in Group 1 were motivated to do PA from the perspective of wanting to live longer with good health benefits, improve mind-body optimization (P11), be mobile, be more active (P08), fit and healthy (P10). The exercises in the app were geared towards body flexibility were seen to be stress-relieving and more relaxing which lead to a mind-body optimization (P11) contrary other apps (Fitbit) in the marketplace.

Interestingly, Group 2 participants felt the need to maintain a healthy lifestyle (P02), aspire to live longer (P21), be independent and mobile prompted more walking (P13). This also encouraged them to do PA like gardening, household chores and trekking (P04). Participants indicated that the tracking of steps provided them the reassurance of reaching their PA targets and to their goal of becoming active, fit and healthy.

In Group 3, overall triggers for PA motivation were to lead a normal life (P12), be mobile and healthy (P25).

Freedom of usage: Participants in Group 1 expressed this to be a value/benefit provided by the Spirit50 app. Key characteristics that allowed for motivated engagement in the app were: ability to understand the steps and timing of the exercise routines. This was because the videos showcased in the app helped to monitor the correctness of the routines and provided flexibility of usage of the app anywhere and anytime and in any attire (home or outdoor). Additionally, simplicity of instructions and simple routines enabled participants to recall routines from memory and do the routines anywhere even without the app. Participants also suggested the inclusion of affordances such as reminder bells, voice commands, timers and adding a variety of routines to choose from. Working with the app also helped with bringing some routine into one participant's daily life that was full of many incidental things that had to be done (P11).

This theme was not evident in Group 2 and Group 3.

Fun and recreation: Overall, this category represented more aspects of motivation to do PA from a generic prescriptive as opposed to specific advantages from using the app or the pedometer. A few responses indicated that accomplishment of the scheduled tasks and the

surprise element of discovering a new way to do difficult exercise in a simple manner became the fun aspect of learning and interacting with the app (P01, P04, P08, P10).

In Group 2, the frustration of having to endure boring exercise routines from online sources and DVDs' for example, encouraged a participant to do more walking with her dog where the fun part was the changing sceneries (P23). Progression with increased step-count on a daily basis added to the competitive nature of the activity and incorporated the fun element (P02).

In Group 3 the aspect of retirement and availability of unlimited time to do anything anywhere and the freedom to do choose different locations to do PA were motivating and fun elements (P12, P25 P27).

Influenced by the app/artifact: Flexibility of using the app anywhere and anytime (P31), appreciation of improved ability (P04), trying out different combinations of the app and regular PA activities (P11) were common motivational elements in Group1.

In Group 2, many participants were receptive to using the pedometer and used it as a tool to monitor their steps, calories and distance travelled (P18). Many participants reported increased number of steps on a daily basis leading to a higher average each week. There was a consistent effort to add more steps to improve their prior daily average (P13, P21).

Group 3 participants did not report any influences from technology artifacts such as Fitbit or Nike-Plus, however relied on their watch as time keepers for their daily routines.

Inspirational influencers: In Group 1, participants were influenced to do more PA by watching team performances (P11), usage of team PA apps by family members and reviews by online fitness experts (P24). Key influencers were: doctors, coaches, physiotherapists and family members (P11, P24, P31). Participants were willing to do the routines provided in the app which were considered to be low intensity (P29). Participants did not find the app routines to be limited by their personal challenges of arthritis, back pain or poor posture and helped to compliment the recommendations from their doctors or physiotherapists (P31).

In Group 2, participants were also influenced positively by younger persons with (buff) toned bodies in their gym environments' (P02). At the same time, participants felt inadequately fit in comparison to younger persons (P12, P23).

Group 3 participants did not report any such influences but relied on the internet for sharing health and wellness information.

Limitations of resources: Participants from Group 1 were challenged by expenses for physical trainers, cost of gym memberships and lack of interest in standard routines (P04). They also faced discouragement due to lack of challenging exercise routines and not being able to make time for daily exercises (P24, P26). While change was frowned upon by a few participants, they preferred to have the option of a variety of routines and a choice of higher intensity routines on the app to supplement their regular routines (P08, P24). However, these limitations were, in fact, the reason to motivate them to do PA and improvise the routines themselves.

From Group 2, inclement weather forced the need to use transportation to get to their gym routines, therefore the use of treadmills was a limitation because they could not adhere to their original routines (P02).

No *limitations of resources* were reported by Group 3 participants.

Mental wellbeing: In Group 1, key characteristics such as desire to overcome lethargy (P04), lower stress, fear of boredom (P10), feeling of failure and guilt for not doing anything (P11) served as triggers for motivating PA. Overcoming sedentary activity (P29), overcoming commitment issues towards enrolling in a routine program (P24) were additional triggers. Participants indicated that the app helped to reminisce about past laurels and fitness successes and desired to overcome their inertia to improve their current effort to doing PA (P24). The app helped to serve as a medium to enable a simple and small-step approach (P29) towards appreciating a set of routine exercises.

In Group 2, participants desire to work outdoors and achieve satisfaction of completing a visually pleasing and satisfying result (P05) motivated them to do PA. Additionally, the guilt of not having done any PA for some time (P13) also goaded them mentally to do some PA.

In Group 3, building up one's self-confidence and overcoming the feeling of laziness (P25), and guilt for doing nothing (P09) coerced participants into doing PA.

Routine/lifestyle: Existing daily routines (P01), self-regulation (P08) and self-monitoring of weekly PA routines (P10) fostered habit formation in Group 1 participants. The app exercises being simple to do and easy to remember provided easy recall during existing scheduled daily activities (P31). It was easy to integrate these app exercises and combine with daily routines (P29) with the added flexibility to increase and lower the intensities at will.

Group 2 and Group 3 participants were set into doing their routine activities of walking and jogging over the past many years leading to habit formation (P05, P18, P27). In Group 2, walking was done routinely and the pedometer helped to reinforce their efforts (P18).

Social connections: All three groups engaged in motivated PA to connect with people and expand their social network while doing their PA. Social connections were not engendered through the app, as this module was not included into the design for this experimental study. However, this motivational category helped reinforce the value of regular fitness due to the realization that they were not alone (G1), and were not singled out in the attempt to maintain and improve their fitness and health (G1). Many participants in G1 wanted to be left alone to their routine activities' in the gym, but wanted the presence of people around them, even if they were not interested in interacting with them. One participant (P24) also suggested a virtual connection with others through the app so that they did not feel that they were doing the PA alone.

In Group 2, participants preferred to compare their step-count with friends and family members (P13, P18, P23). Group 3 participants used their routine PA activity of walking to meet with friends (P07, P09, P14).

Spontaneous and subconscious activity: Participants in Group 1 and 2 were motivated by activities done on the spur of the moment, which were either in their indoor or outdoor activities. Many app exercises afforded the possibility to be done indoors and outdoors. These activities helped generate PA subconsciously leading to more engagement and realisation that their effort was worthwhile which was based on the results of the activity. This also helped to overcome the drudgery (P01, P08) imposed by routine regular fitness exercises. Additionally, the app used in the study helped influence a change in thought process by helping them differentiate and recognize that they were doing valuable PA (P04, P08) when doing regular chores.

Treatment for a health issue: Motivation to participate in PA was also triggered by this category as indicated by the properties gleaned from the participant responses. There was a general consensus of being forced to considering changing sedentary lifestyle by including simple and general fitness routines to overcome health issues. Most properties of participant responses are indicated in the appendix (Appendix 13.8) for each of the groups. While the gravity of the health conditions was specific to individual participants, all three groups indicated using PA as an means to provide treatment for specific health issues.

Participants in Group 1 recognised the value of the app in helping them to understand some of their deficiencies such as lack of arm-strength (P16), bad posture (P04), low upper body strength (P08) to mention a few and resolved to do more specialised training to overcome these issues.

8.7.2 Setting up Goals

The comparison of axial codes also indicates many intrinsic and extrinsic motivation categories emerging from the open coding process. While many of these categories do not directly relate to the usage of technology artifacts, these categories help with a granular understanding of how and why older adults set up goals for PA. Sample participant responses are shown in the appendix (Appendix 13.8).

Combining exercise types: Participants in Group 1 were more interested in combining the flexibility of exercise routines from the app with strengthening exercises. They also wanted the option to select different intensity levels from the app so that they could aspire for to more challenging routines. They preferred to combine sports, app exercises and strengthening routines.

This indicated the desire to combine endurance, flexibility, and strengthening routines to add variety in the collection of PA activities.

Group 2 participants were interested in combining exercise and following their set routines. In Group 3, participants were keen on continuing their set daily routines due to habit and they did not have to complete a set category of exercises. They were also keen on doing PA so that they felt the result of their effort (felt the burn – P16).

Committing time for activity: Participants in Group 1 felt obliged to keep their commitment to stick to a specific routine of activities (eight-week study, yoga, Pilates, gym). As a result, they were dedicated to meeting their time commitment, and they also felt they need to show their trainer what they had done. In comparison to a physical trainer, the presence of a virtual coach in the form of the app was welcomed as long as there was a real person on the screen with an expectation of certain work to be done per week and monitoring of weekly progression. They did not want to let down their coach (virtual coach) and felt obliged to do something even though they would not have felt like doing any PA for a specific week.

Enjoying combination of activities: This category was established separate from *combining exercise types* category indicated prior due to the experiential aspect of participant engagement. The combination of exercise types and activity types (sports, outdoorsy and/or indoor) provided the excitement of competing with people. Encouraging results from competing in sports like activity (hockey, golf) helped to improve their interest in setting up goals for future. From the app perspective, it was suggested to have ‘competing with people’ as a goal setting so that the enjoyment was better.

Focussing on specific goals: Participants in Group1 were keen on setting up goals based on the focus of what their goals aimed to achieve. This contributed towards acknowledging the specificity of the focus of the goals. Recognising their deficiencies through the app, many participants were keen on focussing on immediate goals, rather than short-term goals or long-term goals. This is also because of their reasoning of the possibility of immediate achievable results that could be visually monitored or measured.

In Group 2, small achievable goals such as weight loss, improvement in posture were key characteristics of the concepts for focussing on goals. Walking more to increase step count from 500 steps/day to 10,000 steps/day in a week time was a measurable achievable focused goal for a participant (P23). Reducing excess weight (P18), improving posture and reducing lower back-pain (P13) were a few of the other specific goals from participants.

Focussing on appearance was also a focussed/specific goal for participants in Group1, where participants were keen on ‘*waist management*’ (P11, P24) resulting in either maintaining or reducing one belt buckle position as a measurable specific goal.

Focussing on motivational affordances: In Group 1, measuring progress, results, accomplishing something, and getting rewarded for efforts were indicated by participants’ to be concepts in helping them set up their goals for PA. Checking off a list of activities, receiving points and stars served as validation for their efforts. While participants were not initially keen on such rewards, as they became aware of their progression, they began to notice the presence of the point and stars (in the app) and contributed to their feeling good about their efforts. While many participants in Group 2 indicated that they did not need any badges or rewards, accomplishment of certain tasks (daily walking targets, completing set routines) were rewards in itself. This feeling of achievement was critical to help validate their efforts and helped set up goals for future activities.

Group 3 participants were interested in setting up goals based on doing their daily PA routines such as walking, jogging, tracking distance and measuring weight loss.

Improving health outlook: Setting up goals was also based on participants improving their health outlook. Recognizing benefits of specific PA, reminiscing on past achievable laurels and aspiring to reach past glory helped participants from Group 1 to set up their goals. Overcoming laziness/lethargy to avoid sedentary lifestyle also helped with setting up goals for PA. This enabled participants to remember simple routines and aspiring to be fit and mobile inspired them to do the routines anywhere and anytime.

With participants from Group 2, the challenges of health issues (osteoporosis, arthritis, back pain) forced them to modulate their prior vigorous exercise routines to a more simplified form of walking activity.

Participants from Group 3 wanted to *outlive their pension*, monitor their dietary habits and set up goals based on doing something good to their body.

Increasing challenges progressively: Working on muscle groups, improving their stamina, working on muscle groups, trying to hit daily targets were some of the specific concepts that emerged in Group 1 in this category to help set up their goals. The app served as a medium for them to push for more challenging routines, and, made them realize their potential of progressively increasing their challenges for improvement.

Participants in Group 2 were also keen on adding more walk time to their daily routines to see how far they could push themselves.

Working towards increasing walking and measuring heart rate and weight loss were important concepts from Group 3 participants.

Self-regulating routines: Many participants in Group 1 (P04, P10, P11, P08) indicated the need to control their own routines from the perspective of having the choice to change up exercise intensity based on the flexibility of their schedules and monitoring results. The app helped with setting a schedule for eight-weeks with routine activities. Lack of the option to increase exercise intensity and choice of exercise types was suggested to be a requirement by the participants.

Participants in Group 2 wanted to exercise more control on the amount of time spent on exercise activities like walking, running or riding a bike. The self-regulated the desire to do more and used the pedometer to monitor their progress each day

In Group 3 participants preferred to watch videos and exercise routines on the internet and try out different activities based on their ability and fitness level

Social interaction: Participants in Group 1 were keen on associating with others for companionship in their journey to better health goals (P11, P24). Participating in walkathons, group exercises comparing within a group and with significant others were key characteristics for setting up goals. The suggestion was to have the app connect them with comparing levels and accomplishments of others.

In Group 2, the key concepts in this category was to have a workout partner, to share in the pain and the journey of doing PA.

In Group 3, overcoming loneliness walking with a partner, and comparing distances and time taken for PA with the group or with a spouse was welcomed.

Spontaneous and subconscious activity: This category emerged mainly in Group 1, where participants considered doing exercises to be a forced activity. The best exercise of physical activity was when they did not realise that while they were engrossed in doing their daily routines and scheduled activities, they were actually exerting themselves and getting a good work out.

8.7.3 Feeling of Accomplishment

The comparison of axial codes emerging from within the three groups are as shown in Table 39. I discuss these categories in relation to participant responses (Appendix 13.8).

Adding new challenges: In Group 1, participants were more inclined to feel a sense of accomplishment when noticing an improvement in their flexibility and greater endurance in working out. Feeling confident with existing routines allowed them the opportunity to add new ones and combine different types of PA activities. The simplicity of exercises (app) “...*the exercises are simple and can be done anywhere... (P08)*”, also resulted in participants feeling that they could do more from the point of pushing themselves to more exertion and thereby more points. A few added more routines or participated in outdoor activities (P01, P08, P16).

Participants in Group 2 added more walking to their daily routines for the sole interest of adding more steps to the pedometer (P13, P21).

In Group 3, they went about their daily tasks to keep themselves busy and, when suggested by friends, also took part in competitive outdoor activities.

Influencing activity through app: Feeling of accomplishment was also supported by this category where participants felt that the app helped identify certain deficiencies or short-comings with their self. Realization of one's ability to do better and feeling energetic were also key properties of this category. This category was specific only to Group 1 participants.

Completing difficult challenges: Participants felt that increased intensity of exercise routines, completion of task contributed to the feeling of accomplishment. The aspect of completing a few weeks of the app routines was also a feeling of accomplishment for few participants (P08, P10) because they had started out the program with a lot of skepticism. The app did provide increases in intensity which led to participants feeling more challenged and felt the sense of accomplishment on completion of the activity.

Completing the walking or daily outdoor activities were a few properties from this axial code for Group 2.

Completing the marathon, daily tasks and repair work contributed to participants from Group 3 to feel a sense of accomplishment for this category.

Feeling of mental satisfaction: In Group 1, understanding ones' body to know that it feels better after doing a workout, feeling tiredness in a good way, contentment at the aspect of doing the PA well, were most common properties in this category of mental satisfaction. From an app perspective, the completion of the difficult app routines gave participants the feeling of mental satisfaction contributing to the feeling of accomplishment.

Participants in Group 2 felt energetic (satisfaction of having the energy) and content after completing the outdoor and the PA. The pedometer contributed to pushing participants to do more and feel the satisfaction of completing the activity.

In Group 3, enthusiasm and feeling of achievement contributed to the feeling of happiness leading to mental satisfaction.

Feeling the burn: This category was specifically added because it represented a physiological characteristic contributing to the feeling of accomplishment as opposed to mental satisfaction. This category emerged only in Group 1 and 2. Sample participant responses are given below.

Responses from participants from Group 1 indicated above were in relation to the app exercise routines. While the app exercise routines were low intensity at the start, these responses showed that the intensity of the exercises did increase through the eight-weeks.

Feeling validated for efforts: This category was evident only in Group 1. A few participants indicated that commitment forced effort on their part, and the result of the effort was visible in the form of increased energy to do more, measuring progress and tracking improvements in body condition. The app indicated progression and provided a feeling of accomplishment which helped to validate their efforts in doing PA. Being validated for efforts contributed to a mind-body feeling of accomplishment, and wanting to continue with the eight-week program.

Improving body conditioning: Participants in Group 1 were keen on achieving tighter muscles, toning the body, maintaining weight, improving posture to mention a few concepts that emerged from the coding. The usage of the app exercises did give participants the realization that they could do certain types of exercises, which was considered to be difficult. The usage also helped participants to realize that they were not out of breath when climbing stairs as before (P08), provided the feeling of being able to do wall push-ups (P31), and, gave the awareness to improve on posture. The app also indicated progression and maintenance of these routines enabled participants to understand their weakness and work towards improving them.

In Group 2, feeling relaxed and maintaining body weight, feeling better due to ‘muscle tiredness’ contributed to this category leading to a feeling of accomplishment. Participants indicated that quantifying their efforts on the pedometer helped with wanting to do more.

In Group 3, increased stamina, and the feeling of relaxation due to exercises were concepts in this category leading to a feeling of accomplishment.

Improving confidence: In Group 1, certain app exercise routines like wall push ups, stretch band and exercise ball seated exercises, helped provide participants with increased confidence in their abilities to do certain routines. The feeling of exercise routines being easy to do with increasing intensities along the weeks also provided them with an understanding of their capabilities.

Participants in Group 2 indicated that the ability to do more steps was a point of discovery, and gave them improved confidence leading to a feeling of accomplishment. For one participant, going from 500 steps to more than 10,000 steps per day (P23) was something that was so surprising. The pedometer helped participants to improve prior targets.

In Group 3, participants were keen on being able to do their routine programs and completing them whenever they had the time.

Improving health condition: From the perspective of having a goal and the feeling of accomplishment, participants in Group 1 were interested in overcoming their health conditions like sore hip, back issues, diet control and improve their posture by doing PA. The flexibility exercise routines from the app helped to relieve stress from their body, and the easy recall of these routines helped them use these routines repeatedly.

Group 3 participants had a feeling of accomplishment when they were able to control certain physiological aspects of their body such as: were only keen on walking to control their sugar level without medication or be physically healthy, monitor heart rate and lowering blood pressure.

Improving ability: Participants in Group 1 indicated various characteristics of being able to lift higher weights, increased intensities, and ability to do new routines that were not tried prior, contributed to the feeling of accomplishment in this category. Participants indicated that the app showed them new exercise routines, with newer intensities, and the reps and steps showed their progression on the screen. This indicated their increased ability as the weeks progressed. Participants in Group 2 indicated increased step-counts as they progressed through the weeks (P13, P18, P21).

In Group 3, participants indicated their ability to do the activities that they have been used to doing.

Increasing independence: While many participants indicated that the feeling of independence stemmed from the ability to navigate routines on one's own without help, and ability to do increased intensity exercises, there was no indication of the app facilitating independence from the point of enabling ability. The only independence aspect that was provided by the app was it afforded the freedom to use the app anywhere and anytime.

Inspiring motivational affordances: The resulting codes in this category provided most insights into the feeling of accomplishments of participants leveraged through motivational affordances facilitated through technology. Participants from Group 1 indicated that compliments and feedback provided reassurance of their efforts to contribute to the feeling of accomplishment. Compliments were provided in textual format as a visual check mark for completion with a graphical representation of an icon of a person with raised hands indicating a "hurrah" for completion of the task. Validation for their efforts was recognizable in their positive attitude towards elements like points, stars, progression information, and graphic representation of their effort and completion of tasks. Furthermore, feedback metrics such as reps and steps and timers for exercise completion contributed to a sense of completion leading to a feeling of accomplishment. These findings suggested that reassurance of efforts and validation of work done are key attributes that contributed to the feeling of accomplishment.

For participants from Group 2, the daily step count and increase in step count contributed to the feeling of accomplishment.

Inspiring performance: This category emerged in Group 1 which indicated concepts such as attempting to do exercise routines correctly, pushing oneself to do more and trying to reach peak ability, and, doing more than specified in the app routine. This category was also facilitated by the availability of videos and visual feedback provided through the app interface indicating that inspired performance by the participants led to a feeling of accomplishment.

Progressing through activities: This category was seen across the three groups of participants. While Group 1 participants relied on the app to showcase their progression through the eight-week study, greater emphasis was placed on adding new challenges to existing routines provided by the app. This indicated that participants' self-measures for progressing through activities also indicated the need to be challenged. The combination of exercise intensities, types of exercises (endurance, flexibility and strengthening), and interplaying outdoor and indoor activities provided a feeling of accomplishment

While completing daily routines, and doing more steps in addition to meeting step targets (pedometer) represented concepts for Group 2 in the progressing through activities category,

Group 3 participants indicated that the completion of outdoor household projects and ability to complete asks to be more important measures for progressing through the activity to give them a feeling of accomplishment.

Seeking external resources: This category emerged in Group 1 where a feeling of accomplishment was indicated by following recommendations from fitness instructors, virtual coaches, yoga instructors, physiotherapists and online videos.

Social interaction: There was a mixed response from participants in Group 1 regarding the feeling of accomplishment engendered by social interaction with others. While participants liked to have the presence of people around them in a gym environment, they kept to themselves and

went an about doing their own routines. However, the presence of people around them provided the feeling that they were not alone in the battle for fitness and overcoming weight challenges and the feeling of sedentariness. There were many suggestions for the app to provide virtual connection with other friends and family in an online mode to facilitate the feeling of overcoming loneliness when working out with the app at home or in other places. The presence of people around them had to be acknowledged (physically or virtually); however, interactivity between individuals were kept to a bare minimum level. Feeling of accomplishment was also fostered by working out together but to independent goals as opposed to a combined goal.

For Group 2, the feeling of accomplishment was in comparing workout done by others on the same routine and seeing their own progression. Walking in groups and comparing step counts provided a social interaction and a feeling of accomplishment.

In Group 3, intergenerational play and continuing to walk with friends provided a feeling of accomplishment on a daily basis.

8.7.4 Fears and Barriers

While fears and barriers prevented participation in PA, codes that emerged indicated challenging health conditions, fearing inability, appearance issues, psychological challenges, limitations of resources, lack of confidence, lack of performance and being afraid of social interactions to be primary categories for this question. These are detailed in Table 40. However, with regards to technology facilitation, in Group 1, the challenges with smartphones and apps taking on a “Big Brother” (P11) approach leading to invasion of privacy was a major concern. This participant refused to purchase a cellphone due to this barrier and did all the exercise routines on his desktop. Challenges of not having access to technology (desktop, app or smartphones) at the desired time of wanting to do exercise routines were other barriers related to technology and PA (P04, P08). Compared to the ease of using a mobile device, one participant considered the challenges of having to operate a desktop to be a barrier (P04). Detailed sample participant responses are outlined in the appendix (Appendix 13.8).

In Group 2, while many embraced technology and the pedometer, one participant was afraid that monitoring would trigger her past nature of obsessively measuring weight, calorie intake, calories burnt and even measuring the amount of wine consumed each week (P23).

While the control group participants did not allay any fears with technology; the properties of their fears and barriers to exercise are shown in appendix (13.8).

8.7.5 Rewards and PA

From CET, the type of rewards (Section 3.1) can also help to foster intrinsic motivation and behaviour (Deci, Cascio, & Krusell, 1975). Participants indicated a lot of interest in the types of rewards associated with physical activity. While many rewards expressed by the participants were intrinsically driven, there were many instances of being encouraged for PA due to the presence of extrinsic rewards which included: progression bar, completion of tasks, points and stars. I discuss these in relation to technology facilitation and PA. In Group 1, many participants were encouraged by immediate rewards, long-term rewards, intangible rewards and tangible rewards. While immediate and long-term rewards could be either intrinsic or extrinsic, there were indication of further segregation of these into tangible and intangible rewards. Detailed sample participant responses are outlined in the appendix (13.8).

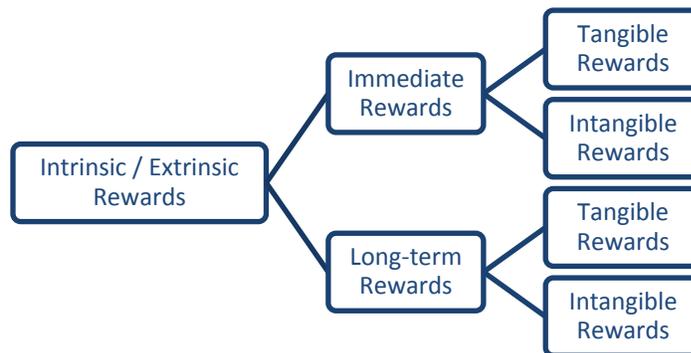


Figure 42: Rewards Categorization

Completing an Activity: Within this category, completing an activity was a type of immediate, intangible intrinsic reward. The satisfaction of completion, feeling good after a workout, feeling relieved that the work was done, enjoyment of tiredness and being conscious (aware) of benefits were examples of immediate, intangible, intrinsic rewards. From a technology facilitation perspective, many participants indicated that receiving points and stars, seeing their progression

across the top of the app along the course of the eight-weeks (immediate, tangible, extrinsic rewards) provided reassurance (confident of ability as a reward) for the work done and validation of their efforts. The app fostered the possibility of replaying the video so that the exercises could be done correctly.

Participants in Group 2 also indicated that steps tracking with the pedometer provided a sense of relief in completing the task and was a good feeling to see numbers increase every day.

Participants in Group 3 were happy in getting the task done.

Having freedom of usage: The feeling of having the freedom to use the app anywhere and anytime was a benefit and a reward because the app afforded the possibility of feeling good when using the app. “...*you are able to do the exercises...in your pyjamas...while waiting for your eggs to boil...*” (P31). This participant was able to use the app on her iPad. While the app in its current format was usable only on desktops, the technology provided a fitness-on-the-go approach, a concept that was appreciated by many.

Participants from Group 2 expressed the freedom to walk anytime anywhere with tracking metrics.

Having intangible rewards: Feeling important due to personalization of the app and, feeling good at receiving checkmarks for completing a routine were key properties of this category leading to rewards. Sincere praise from a PT or feedback from virtual trainers for task completion were also intangible rewards indicated to be fostered by technology.

In Group 2, the satisfaction of reaching pedometer steps and feeling energetic and vibrant after an exercise routine were key properties of this category leading to intangible rewards.

Group 3 participants felt getting complimented by others and doing the routines correctly contributed to intangible rewards.

Having tangible rewards: Many participants indicated rewarding themselves with cake, beer, wine, sweets and bread, on completion of the PA routines. In Group 1, from a technology facilitation perspective, gaining points doing the flexibility routines and aiming for smaller sized pants/trousers, weight loss, and unchanged belt buckle position were a few properties of this category. Motivation to participate in PA to earn these rewards was noted in a few participants (P10, P24, P31). The tangible rewards provided validation of their efforts (P10).

Group 2 participants were keen on seeing an increase in number of steps on the pedometer (P02, P13, P18, P21). This milestone led to them rewarding themselves with sweets and ice cream occasionally (P02, P21).

Group 3 participants sometimes rewarded themselves with snacks, coffee pizza and beer.

Feeling of mental satisfaction: This category represented the enjoyment and engagement experiences of participants from a PA perspective. When comparing the properties of the open codes and axial codes most participants from all the three groups expressed that the feeling of mental satisfaction stemmed from being less tired in doing the same routines on a weekly basis, seeing a visual improvement in their appearance, feeling energetic and meeting daily targets. Completion of PA tasks was a desirable characteristic among participants in all the three groups.

From a technology facilitation perspective, participants in Group 1 indicated that feedback elements, seeing progression in daily activities and seeing the point's number increase contributed to mental satisfaction leading to rewards.

Satisfaction from reaching daily targets on the pedometer provided participants from Group 2 a sense of reward: “...often (as a reward) the feeling of energy and completion is good...” (P13); “...just hard work makes me feel good...and is a reward in itself...” (P18).

Participants from Group 3 felt satisfied because of the feeling good aspect after completing the PA: “...there were no specific rewards just a good feeling that I had a good week...” (P27).

Having self-awareness: Another type of reward that emerged was the feeling of self-awareness, which was contributed to by understanding their deficiencies and overcoming laziness. This category emerged in Group 1 and Group 2. From a technology facilitation perspective, the app helped participants to be aware of lower upper-body strength, lower arm strength and the need for a sense of discipline to be able to meet set daily challenges or targets posted by the app.

Experiencing a feeling of discipline and the desire to do more were a few properties that emerged from Group 2. This theme was not evident in Group 3.

Having sense of accomplishment: While participants from Group 1 maintained that getting things done, increasing challenges or exercise intensities, many participants did more than what was asked for in the app (P10, P11, P31).

Reaching daily targets (pedometer) was a key characteristic of having a sense of accomplishment leading to rewarding PA (P02, P13, P21).

Participating and competing PA like a half-marathon (P25) led to a sense of accomplishment leading to a feeling of reward.

Improving confidence: Interestingly this category emerged from Group 1 and Group 2. Participants from Group 1 attributed the app to making them feel competent leading to a feeling of reward. “...the app showed me that I could do wall push-ups, I could never do push-ups, and now I am bragging to my friends in my age group that I can do this” (P31). “...it is like an inspiration to do more activity or exercises” (P04). Simplified age-centric exercise routines fostered this feeling of confidence in themselves. The points helped reassure that they completed the routines and were able to move on to the next exercise routine or the next level (day). In Group 2, being competent was critical to participants to overcome the stereotypical notion that older persons were sedentary. “...and the feeling of being competent ...being competent is my reward and at my age, I first need to be active and then comes the health...” (P23); “I started out ...you know at 500 steps per day...and now I am doing more than 10K per day... (P23)”.

This contributed to feeling confident and competent to do PA, leading to a feeling of reward in both groups.

Improving health condition: Rewards were also about achievement of better health due to PA. For participants in Group 1, improved breathing due to the app exercises, improvement in posture, lower blood sugar levels due to exercise and not being out of breath were some of the properties of this category. While these could be attributed to any exercise routine, the technology facilitation for participants from this group was that the app indicated their progression through the eight-week program, and when they put themselves to reality challenges, they were able to perform at a better level.

Participants in Group 2 and Group 3 were keen on lowering their blood-sugar level through exercises. Improving health conditions was an intangible, long term reward and inspired a feeling of attainable goal.

Inspiring motivational affordances: Participants in Group1 indicated that technology facilitation of PA through motivational affordances provided them with a feeling of immediate, tangible and extrinsic rewards. These rewards fostered a sense of competence, a sense of accomplishment, a sense of being validated for their efforts, a sense of reassurance that they could do the routines and progress through the eight-week study.

Frustration also stemmed from the fact that the progress bar moved quite slowly (P26) in relation to the workouts remaining to be done in the eight-week program. Participants (P08, P31) also wanted the opportunity to do more exercises on the same day to gain more points and add to the visual progression or achieve higher challenge levels.

Participants from Group 2 were keen on step count and receiving badges for completing certain challenges like adding more difficulty levels like climbing hills and seeing progress through the week.

Participants in Group 3 were keen on completing their routine tasks.

Seeing results of efforts: Participants in all the three groups indicated that seeing the results of their efforts led to the feeling of being rewarded. In Group 1, in addition to their daily activities, the progression bar, the checkmark for having done the exercise routines, indication of completion of the reps and steps provided a result oriented interface for the participants. Additionally, participants also started to include a heart monitor (P10, P11) to identify their heart rates pre-and post-test situation and also indicated that a calorie burn indicator synced with the app would be a good addition.

Participants in Group 2 noted pedometer reading each day and expressed that reaching daily targets was reward in itself.

In Group 3, time taken for the daily routine, and feeling of tiredness was a measure of the result of one's effort leading to a feeling of reward in doing PA.

Social activity: Comparing one's progress with a running partner of a spouse were key rewards attributes for participants from all the three groups. While the app and the pedometer did not have features to enable social comparison of progression, participants voiced their interest in being able to do such a comparison.

In Group 2, running with a partner, comparing activities done (P02, P18) on specific routines and step count provides a sense of rewarding social activity.

Running for companionship and sharing experiences and life's challenges were key properties of rewarding social activity for Group 3 participants.

8.7.6 Tracking and PA

While there were many positive attributes to tracking and PA, there participants did indicate the negative aspects of tracking. Engagement in PA can be affected by these negative attributes; I discuss these positive and negative properties of the axial codes that emerged from the qualitative data. All of these axial codes relate distinctively to technology facilitation of PA. Detailed participant responses are indicated in the appendix (Appendix 13.8).

Challenging tracking issues: A few participants in Group 1 were concerned that technology tracking of their movements and locations would be an invasion of privacy (P08, P11), and voiced concern that monitoring numbers would be a *botheration* (P08) and would make them *obsessive* (P11) and did not want to *punish themselves* (P08). Additionally, one participant indicated that the *inclination would be low* if the data had to be input each time (P29).

A few participants in Group 2 indicated that the tracking of inactive time would be good and would be a trigger to do more PA (P13, P23). Additionally, low numbers and not being fixated by numbers were additional tracking challenges from this group.

Group 3 participants did not give any feedback regarding challenges in tracking for PA.

Indicating completion status: A few participants from Group 1 were happy to see a completion status (P01), a checkmark (P08) or striking off from a list (P08, P11).

Participants from Group 2 wanted to see a comparison of steps done daily with the steps done in the past.

Participants from Group 3 wanted to see the amount of time taken to do a regular routine like walking (P15), time to destination (P25) and distance to go (P20).

Improving body form: Most participants from Group 1 indicated that improving body shape, form and posture were very important for them. The app indicated reps and steps for each exercise routine which was used to do more PA. Many participants suggested the advantages of a automatic form checker and gait/posture improvement possibility in the app.

Participants in Group 2 indicated that in addition to step count they would welcome a feature that would help them improve their posture and gait when walking.

In Group 3 participants were more interested in reviewing their body improvements in the mirror and measuring weigh loss on a daily basis.

Indicating motivational affordances: Participants (Group 1) indicated technology facilitation of PA was fostered in this category by recognizing the value of recording progression, achievements check marked on a list of routines, time duration of routines and increasing challenges provided on a weekly basis. While a few participants did not notice the presence of points and stars, in the beginning, many participants did acknowledge that the points and stars served to validate their efforts and indicated their progression through the app program.

Participants from Group 2 clearly indicate the desire to maintain their daily walking targets and also trying to do better on each occasion.

Participants from Group 3 did not indicate any motivational affordance.

Making social connections: Participants from Group 1 indicated that comparing progress with a spouse or a partner gave them confidence to do more. However, the app did not have this feature enabled in the present format to acknowledge any social comparison. One participant (P24) indicated the possibility of overcoming loneliness through the app by the comment “...*it would be good to connect with other participants working on similar routines so that they would not feel that they are doing this alone at 10 pm on a Sunday evening...*”

In Group 2, participants (P02, P18, P21) were keen on comparing with persons of the same age, which helped to reassure them that their efforts were in the right direction.

Group 3 participants (P07, P09, P14, P20) were more interested in the social aspects of walking and doing exercises together.

Needing feedback: From a tracking perspective, participants in Group 1 indicated that the app provided feedback on progression (daily and weekly), number of reps and steps done per day and provided video information on the correct method of doing the exercise routines. Participants’ suggestions were to use the app as a reminder to initiate the process of doing the exercise and provide notes of encouragement and progression on a daily basis. Presence of a virtual coach as

indicated in the app helped reaffirm their desire to do the app routines, however, participants suggested that getting real-time feedback from the virtual coach would be beneficial to their improvement and confidence the correctness of their routines.

Participants in Group 2 and 3 needed feedback on weight loss and improvement in their daily activities.

Measuring physical activity: Participants from Group 1 and 2 indicated measuring of physical metrics such as weight loss on a daily basis, calories burnt, calorie intake and heart rate on an intermittent basis. Quantifying PA for regular activities was defined by time duration of activity, distance walked/run and steps done. Furthermore, in Group 1, app elements such as progression, points earned, challenge levels on a weekly basis and, score and stars contributed to the validation of effort done in a PA.

Participants in Group 3 indicated that measuring time duration for PA and weigh loss reassured them about their progress in daily tasks and fitness goals.

8.8 Technology Facilitation of PA

Older adults are interested in various aspects of gamified technology (Sections 8.6, 8.7) because specific elements within the gamified PA system provided advantages such as: keeping on track with regular PA, ability to recognize their limitations with exercise intensities, challenge themselves to do more, feel validated for their efforts and be rewarded for their task completion stages. While older adults may have limited understanding of terminologies such as gamification and motivational affordances, they do respond to triggers such as: setting up of attainable goals, on-the-spur of the moment challenges and pushing themselves to do more PA, also supported by prior non-gamified intervention studies (Kappen et al., 2016; Tabak et al., 2015). Additionally, qualitative and quantitative analyses indicated that the quantification of PA using tracking metrics and pedometers also pushed older adults to walk more, add new challenges in their routine walks or treks adding to the degree of difficulty of their activity and also increase the time spent on such activity. These findings extend the results of prior studies on PA and older adults using gaming technologies (Brox et al., 2017; Far et al., 2015). Furthermore, the presence

of motivational affordances also provided older adults with the choice of monitoring their progression, keeping track of their achievements, and giving them an improved sense of control of their efforts for PA. Additionally, these findings extend the results of prior studies on improving PA in older adults through mail-based interventions (Martinson et al., 2008; Denise Astrid Peels et al., 2013) to the context of gamified PA interventions.

To understand older adults' enjoyment and experiential aspects of using technology for PA, it was critical to examine the relevance of technology in the context of PA motivation, setting up goals, feeling of accomplishments, fears and barriers, and rewards, and tracking. By investigating the influence of gamification elements in PA technology, this thesis extends prior work of using web-based interventions to promote PA by sedentary older adults (55+) (Irvine et al., 2013), supporting improved behavioural changes and effective changes in PA of older adults (50+) (Denise A. Peels et al., 2012) due to computer-tailored interventions and justifying the need for improved web-based interventions for older adults (50+) for better sustainability (van Stralen, de Vries, Bolman, Mudde, & Lechner, 2010).

Based on the thematic analysis, the evidential chain (Miles et al., 2014) indicating the justification of gamified PA technology for older adults is illustrated (Figure 43). While qualitative analysis has been used by researchers for hypothesis testing, the analysis provides evidence of technology influencing PA. This supports the hypothesis that (Section 4.5.1) that gamified PA applications would increase participant engagement and motivation in PA activity (H1, H2). The evidential chain for technology facilitation of PA (Figure 43) is created based on the findings from the qualitative and quantitative analysis outlined in Section 8.6 and 8.7 as shown in Table 45. The first column represents the main research question, the second column represents the categories of deductive generalizable categories as explained in Section 8.4.1, the third column represents the motivational affordances that were findings from the analyses indicated in Section 8.6 and 8.7. The category on *fears and barriers for PA* was not included this illustration because the themes from this category were not gamification elements. The last column represents properties of motivational affordances as evident from participant responses.

Evidential Chain			
Research question (Column 1 of Figure 43)	Intrinsic and extrinsic categories (Column 2 of Figure 43)	Motivational affordances (Column 3 of Figure 43)	Properties/attributes (Column 4 of Figure 43)
Can gamification be used to facilitate PA in older adults?	<ol style="list-style-type: none"> 1. Motivation for PA 2. Setting up goals in PA 3. Accomplishments in PA 4. Rewards and PA 5. Tracking of PA 	Motivational affordances for each of the five categories	Properties/attributes of motivational affordances indicated in column 4

[Table 45: Evidential chain design \[218\]](#)

This table is illustrated as a pictorial representation in Figure 43.

Figure 43

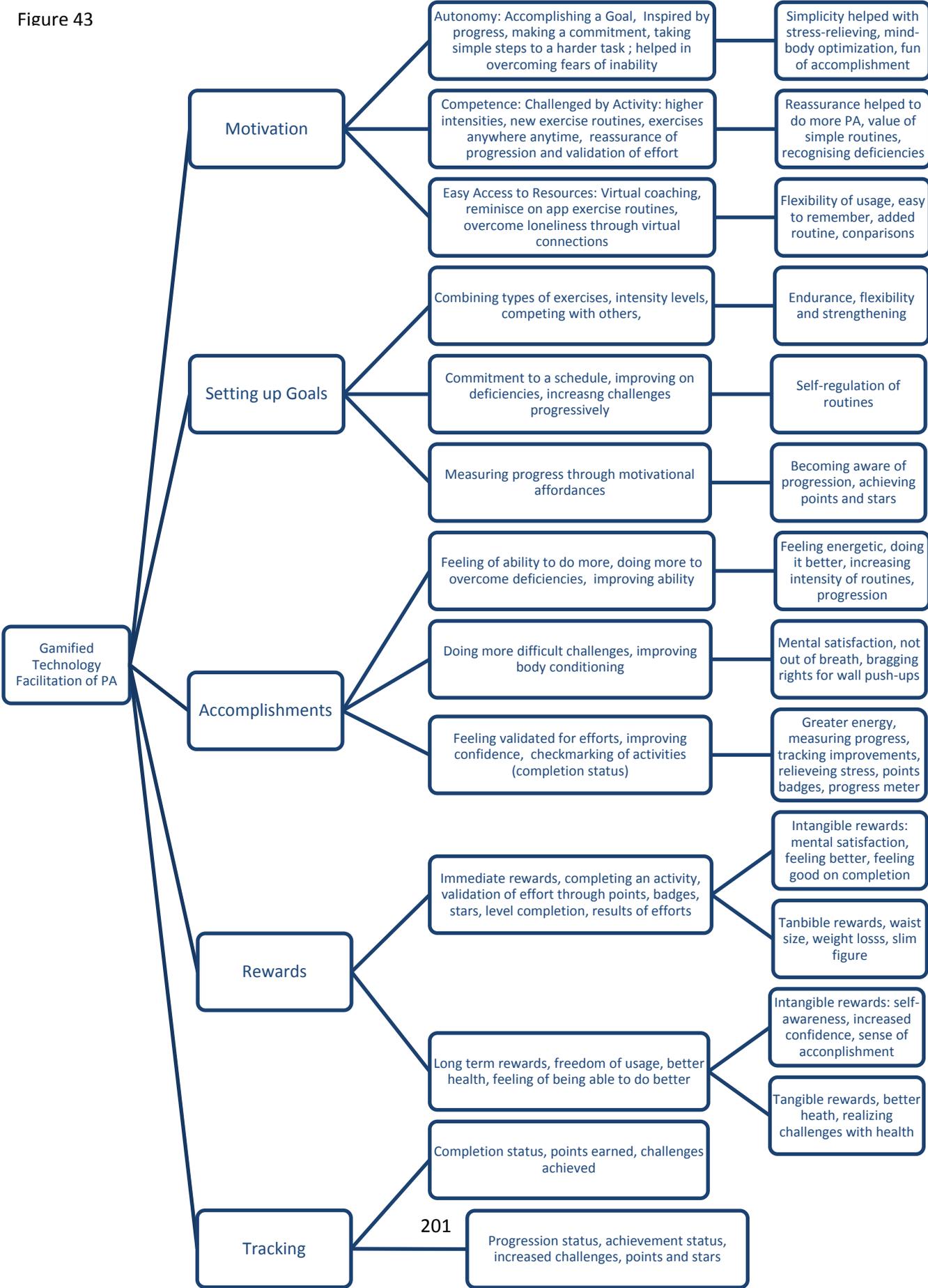


Figure 43: Evidence Chain of Motivational Affordances for PA from Qualitative Analysis

The above evidential chain indicates congruence between findings from qualitative and quantitative data analysis where within the constructs of motivation posited by SDT, *autonomy* and *competence* were fostered by gamification elements within the Spirit50 application.

From the quantitative analysis, overall needs satisfaction for exercise (PNSE) indicated significance for perceived competence, perceived autonomy and perceived relatedness. The Jonckheere-Terpstra test, used to compare trends between the groups, also revealed rising medians towards the gamified group for dimensions relating to interest/enjoyment, perceived competence (for interventions), effort/importance, perceived choice and value/usefulness. This result is also similar based on the axial codes that emerged from the qualitative analysis indicated in the evidential chain mapping (Figure 43) that the gamified group participants showed interest and enjoyment by the following: improving on their deficiencies, increasing challenges progressively, indicated perceived competence through increasing challenges progressively, feeling of the ability to do more and increasing difficulty levels, feeling importance of effort/importance by feeling validated for their efforts, measuring progress and improvement in body conditioning. Perceived choice was afforded by the ability to select goals and challenges, self-regulation of routines and flexibility of usage. Furthermore, value/usefulness was afforded by feeling energetic, wanting to do more, improved confidence and improving ability.

The results of the follow-up tests in the quantitative analysis for needs satisfaction for exercise (PNSE) indicated significant results between the gamified group and non-gamified for perceived competence, and between the gamified and control group for the same dimension. This was also similar to the axial codes emerging from the qualitative analysis indicating that participants in the gamified group felt that a scheduled program with daily achievements and challenges with motivational affordances like points and stars (rewards) helped them feel that there was validation of their efforts, and provided constant monitoring of their progress.

The Spirit50 app had minimal social interaction options included for testing and therefore it was surprising to note that the gamified group indicated significant difference from non-gamified and

control group for the relatedness dimension. In comparing the qualitative data from the gamified group, many participants indicated that they could see the potential of social interactions with other online participants of the app and in their own daily life.

8.9 Summary

Motivational affordances or gamification elements have been used in many areas for increasing the engagement and motivation of consumers or users in the domains of marketing, education, health and wellbeing, and crowdsourcing to mention a few. There has been limited research in the usage of gamification elements to facilitate motivation and engagement of users in a physical activity setting, especially for the older adult demographic. This chapter builds on the guidelines for age-centric PA that were explained in Chapter 6. The chapter explains a mixed-method, eight-week, experimental study which randomized 30 participants over 50 years of age into Group 1 (gamified), Group 2 (non-gamified) and a control group. Group 1 used Spirit50, a gamified PA technology (Group 1) that enabled participants to customize their exercise plan over an eight-week period, Group 2 participants used pedometers - non-gamified technology during their PA sessions over an eight-week period. The participants from the control group continued to do their daily PA sessions as usual.

Using thematic analysis, findings from qualitative analysis indicated that the gamified group showed more engagement and interest in performing PA facilitated by technology over an eight-week period. Results from quantitative analysis indicated significance in the perceived competence dimension compared to the non-gamified and the control group. Perceived autonomy was significant for the non-gamified group against the control group. This congruence between the findings from the qualitative and quantitative analysis rejects my null hypothesis that there was no change between the groups as measured by motivation, enjoyment and engagement. Furthermore, the findings also support my hypotheses (H1 and H2) that enjoyment and engagement is less in groups with traditional PA interventions than due to the usage of gamification elements in PA technology. This further indicated that gamification elements can be customized to participants for the 50+ age group and tailored to suit their current health conditions and prevalent barriers to participate in PA.

The next chapter discusses the expert evaluation of motivational affordances for technology facilitated PA using Spirit50, the gamification artifact in order to help improve the applicability, usefulness and ease of use for the older demographic.

Chapter 9

9 Phase 5: Expert Evaluation

In the specific context of this research, an expert evaluation was sought for reviewing the motivational affordances emerging from the experimental study (Chapter 8) and technology facilitation of PA using Spirit50, a gamified application to help older adults participate in physical activities through daily and weekly exercise routines. Motivational affordances from the users helped with creating the mapping of motivational affordances for PA technology. However, based on user experience research, it was important to review the technology mapping with experts to evaluate these motivational affordances in the context of older adults PA motivation. For this reason, Spirit50 was used as a medium to evaluate the relevance of these motivational affordances.

9.1 Expert Evaluation

Expert evaluations are normally conducted to inspect an application or a tool from the vantage point of applicability and usability (J. Nielsen, 1994; Jakob Nielsen, 1992). An expert heuristic evaluation, or expert review, is a method of assessing a product or service for its usefulness, applicability and ease of use (Desurvire, Desurvire, Blvd, Rey, & Caplan, 2016; L. E. Nacke, Drachen, Kuikkaniemi, & Kort, 2009; Paavilainen, 2010). A panel of experts from multidisciplinary domains spanning HCI, computer science, game design and gamification were identified and sent requests for participation in the expert evaluation process.

9.2 Objectives of the Expert Evaluation

Motivational affordances (Juho Hamari et al., 2014; Lister et al., 2014) for PA facilitation are elements which help facilitate intrinsic or extrinsic motives to participate in PA. Gamification is essentially applying strategies from game design (e.g., mechanics, dynamics, and aesthetics) to daily activities to make people's actions more engaging. As indicated in prior sections, gamification has been defined as using game elements in non-game contexts. In this expert

evaluation "Motivational Affordances" and "Gamification Elements" terms were used interchangeably.

Participation as an expert for this study was requested from researchers and/or experienced professionals from the following fields: game design, gamification, games user research. Experts were recruited to evaluate the technology artifact (Spirit50.com) for the following objectives:

1. Evaluating motivational affordances for technology facilitated PA
2. Evaluating the usefulness of the Spirit50 application
3. Evaluating the ease of use of the Spirit50 application

9.3 Method

While the user testing of the Spirit 50 design (Chapter 7) helped to resolve usability and interaction issues, the experimental study (Chapter 8) provided motivational affordances guidelines for technology facilitated PA (Figure 43). Furthermore, an expert evaluation of these questions using a long-form (LF) questionnaire (Appendix 13.11.2) and a gamification heuristics evaluation tool (Tondello, Kappen, et al., 2016) was carried out. Spirit50 was used as the gamified technology for this expert evaluation process because, to the best of my knowledge, it was the only gamified technology designed specifically for older adults and tailored to their age-related abilities.

Design

In Chapter 8, Spirit50 was the technology artifact that was used in the intervention study described. A backup Spirit50 site was set up on a separate server so that it would not conflict with the commercial version of the site. Details of this application's design is provided in Chapter 7.

Participants

Seventeen experts in the domain of gamification and HCI were invited to participate in the expert evaluation as part of the recruitment process. Of these, 12 agreed to participate in the expert evaluation study. Three experts were unable to complete the expert evaluation process

which resulted in a final count of nine experts (F=1, M=8) representing gamification (n = 5), games user research (n = 2), human computer interaction (n = 2). Seven of them had Masters Degrees and two held Doctorates. Five experts averaged four years and six months of expertise in gamification or gameful design. The most experienced expert had more than seven years' experience, while the least experienced was two years. The experts were invited to evaluate motivational affordances and its usage, usefulness and ease of use of Spirit50.

Materials

Spirit50 is a web application designed with gamification elements for older adults over 50 years of age. Spirit50 incorporated the following gamification elements (motivational affordances): goal definition (quest), daily challenges, goal progression meter, points and badges (stars), roadmaps, daily challenges, weekly challenges and accolades for completing activities as motivational affordances (gamification). While results from the eight-week intervention study (Chapter 8) indicated benefits of these affordances, expert evaluation was sought to further investigate the motivational affordances used in the application, applicability and usefulness of this technology artifact.

Procedure

The expert evaluation was conducted in two stages.

Stage 1: Experts were provided a link to the cloned Spirit50 site and given a login and password for remote access to the Spirit50 site. A detailed PowerPoint was provided with instructions on setting up password and how to select the eight-week option. This backup was a clone of the commercial site. For this reason, a discount code had to be set up so that experts would not have to pay for the site during evaluation. They were encouraged to use the web application as a user and evaluate the process of setting up their goals to exercise, input current health challenges, and select known barriers to exercising. They were asked to explore the aspect of setting up their eight-week fitness roadmap for the specific goal of “Getting up and down off the floor with ease”. This specific goal was chosen because it was the same specific goal used by participants in the experimental study described in Chapter 7. All experts evaluated the activities offered on the site and were also encouraged to perform the tasks suggested by the application. This process

was targeted to not take more than 30 minutes of evaluation time. Experts were free to explore the application for more time should they felt the need to do so.

Stage 2: Once the evaluation phase as completed, experts performed an online independent assessment of the application using a survey questionnaire. The survey questionnaire posed questions for motivational affordances from the Heuristics Evaluation for Gameful (HEG) design, a heuristic toolkit, designed for gamification applications (Tondello, Kappen, et al., 2016) and also consisted of long form questions pertinent to applicability of the Spirit50 for the older adult demographic and its usefulness. The questionnaire was set up on *LimeSurvey*, an open source survey platform on a secure password protected site.

9.4 Results

The data from the expert evaluation was saved through *LimeSurvey* and exported to SPSS for quantitative analysis. Content analysis was carried out for answers to long form questions. I report the results of the content analysis of the long form questions followed by the quantitative analysis of the HEG toolkit.

9.4.1 Qualitative Content Analysis

Detailed qualitative content analysis (Klaus Krippendorff, 2013; Schreier, 2012) (QCA) of long-form questions asked of expert evaluators and specific quotes from experts are shown in Appendix 13.11.2. In this section, I provide consolidated results of the analysis for each question.

Question LF1: *Do you think any specific gamification elements/motivational affordances/game elements should be given higher importance than others?*

The details of specific gamification elements that were indicated to have higher importance are shown in Table 46.

<i>LF1</i>	<i>Do you think any specific gamification elements/motivational affordances/game elements should be given higher importance than others?</i>									
EX01	EX03	EX04	EX05	EX07	EX08	EX11	EX12	EX20	n	%age
goals	goals	goals	goals			goals		goals	6	19%
	points	points		points				points	4	13%

achievement					achievement		achievement	3	10%
				ability	ability	ability		3	10%
competence				competence				2	6%
mastery						mastery		2	6%
	progress bar						progress bar	2	6%
		improved performance					improved performance	2	6%
	feedback			feedback				2	6%
				stars			stars	2	6%
				commenting				1	3%
			competition					1	3%
			collaboration					1	3%
							Total	31	100%

Table 46: Gamification Elements in Order of Importance

From an *intrinsic motivation* perspective, the experts suggested the following: focus on goal achievement, prioritizing competency, mastery of doing tasks, and increasing challenge choices. The app should facilitate an increase in ability, allow users to meet goals, and encourage task completion.

Opportunities for collaborative and non-competitive elements, ability to comment on the performance of others, produce content for others and build a community for PA motivation would help with prioritizing motivational affordances with the *relatedness* construct of SDT.

Accentuating rewards and progression, showcasing performance and progression through progress graphs, additional usage of points earned to either purchase quests or challenges with increased difficulty would facilitate *extrinsic motivation* for PA.

While Spirit50, in its current format, used gamification elements like goals, challenges, reward system (points, stars and completion badges), and progress indicators, the reward mechanism was not clearly visible at first glance. The experts indicated that in its current format, the progress bar needed a lot a PA to be done, to show even a small movement in the progress bar.

Question LF2: *In your expert opinion, what other gamification elements/motivational affordances/game elements would be more impactful in the context of the Spirit50 application?*

Increased choice for users, randomness of newer activities, unexpected events, opportunities for learning about the importance of PA being done and onboarding would foster autonomy (choice of selection) within the intrinsic motivation dimension. Facilitating mastery of activities leading to *competence* in specific routines was also indicated to be an impactful gamification element.

The details of specific gamification elements that would have had more impact in the context of the Spirit50 app are shown in Table 47.

<i>What other gamification elements/motivational affordances/game elements would be more impactful in the context of the Spirit50 application?</i>											
LF2	EX01	EX03	EX04	EX05	EX07	EX08	EX11	EX12	EX20	n	%age
		chal- lenges	chal- lenges	chal- lenges	chal- lenges		chal- lenges	chal- lenges		6	12%
		goals		goals		goals	goals		goals	5	10%
choice				choice		choice		choice	choice	5	10%
					ability	ability	ability	ability		4	8%
		stars			stars		stars		stars	4	8%
socializat ion					socializa tion	sociali zation	socializ ation			4	8%
					points		points		points	3	6%
				achieve- ment			achieve- ment		achieve- ment	3	6%
mastery			mastery					mastery		3	6%
		progress bar						progress bar	progress bar	3	6%
compari- son					compari son				compari son	3	6%
competence						compe tence				2	4%
						leader- board		leader- board		2	4%
	feedback				feed- back					2	4%
					commen ting	com- mentin g				2	4%
				collabor ation				collabor ation		2	4%
freedom									freedom	2	4%
				competit ion						1	2%
		onboard ing								1	2%
					content creation					1	2%

								avatars	1	2%
randomness									1	2%
								Total	51	100%

Table 47: Impactful Gamification Elements

Ability to express sentiments (+ve or -ve), compare progression with others, increased socialization, as well as the presence of leaderboards, commenting options, and the ability to create avatars in their personal profile, could facilitate *relatedness*.

Additionally, exaggerating progression, increased reward mechanics for effort done, greater visibility of rewards, as well as showcasing daily task completion and progression, would be more impactful in facilitating *extrinsic motivation* for PA.

Question LF3: Do you think that the application provided adequate feedback to the participants?

As shown in Table 48, experts indicated that the Spirit50 provided feedback on progress, points and stars earned and completion status. However, experts indicated that older adults needed more guidance and intermittent feedback regarding progress and performance to validate the correctness of their efforts.

LF3	Do you think that the application provided adequate feedback to the participants?									
EX01	EX03	EX04	EX05	EX07	EX08	EX11	EX12	EX20	n	%age
progress bar	progress bar	progress bar	progress bar	progress bar		progress bar	progress bar	progress bar	8	21%
points	points		points	points		points		points	6	15%
	stars		stars	stars		stars		stars	5	13%
completion status			Completion status	completion status		completion status		completion status	5	13%
timer		timer		timer	timer			timer	5	13%
more feedback required	more feedback required		more feedback required		more feedback required	more feedback required			5	13%
more progress details		more progress details					more progress details		3	8%
		onboarding required					onboarding required		2	5%
								Total	39	100%

Table 48: Aptness of Feedback Elements in Spirit50

Explanations of the value or importance of the exercises being done and the benefits of specific routines could also help instil confidence in older adults to do more. One expert (EX20) also indicated that lack of feedback or unclear feedback could lead to frustration resulting in a lack of engagement.

Furthermore, points and stars that were rewards for completing challenges were barely visible. Providing proportional movement of the progress bar, and providing feedback on self-reported challenges could help provide better feedback to users regarding their interactions with the app.

Question LF4: *If feedback provided in the Spirit50 application was not adequate, can you suggest any pointers to improve the feedback to potential users?*

Experts suggested the inclusion of feedback indicating contributions of exercises towards a specific goal, reasons for fitness intensity based on health conditions, explanations of the value (health benefit) of the specificity of the exercise routine, and iterative feedback could help with reassuring older adults in experimenting with this app (Table 49).

<i>If feedback provided in the Spirit50 application was not adequate, can you suggest any pointers to improve the feedback to potential users?</i>											
LF4	EX01	EX03	EX04	EX05	EX07	EX08	EX11	EX12	EX20	n	%a ge
feed- back on correct- ness				feedback on correctnes s	feedbac k on correct- ness	feedback on correctnes s	feedback on correctnes s	feedback on correctnes s		6	16%
	feedbac k on challeng es			feedback on challenges			feedback on challenges	feedback on challenges	feedbac k on challeng es	5	14%
feed- back on value of exerci- ses				feedback on value of exercises			feedback on value of exercises		feedbac k on value of exercise s	4	11%
more feed- back on perform ance				more feedback on perform- ance		more feedback on performan ce	more feedback on performan ce			4	11%
		onboard ing			onboard ing			onboardin g	onboard ing	4	11%
exercise to goal contribu tion					exercise to goal contribu tion				exercise to goal contribu tion	3	8%
feed- back	feedbac k about rewards				feedbac k about rewards					3	8%

about rewards										
feedback on importance of exercises				feedback on importance of exercises				feedback on importance of exercises		3 8%
	recommended intensity of exercises							recommended intensity of exercises		2 5%
	feedback on points usage							feedback on points usage		2 5%
		reason for timer								1 3%
									Total	37 100%

Table 49: Suggested Feedback Elements for Spirit50

Additionally, quantifying points to types of exercise, an improved progress bar synchronising performance/effort versus progression, emphasizing rewards and a better dashboard for feedback and infographics could help improve the app.

Question LF5: *From an expert evaluation perspective, please list a few limitations of the Spirit50 application, if any?*

Experts indicated that in its current format, from the perspective of *autonomy*, a few limitations of the app were: lack of graphic visualization of progression, limited onboarding, the availability of selection of only one specific goal at a time, lack of choice in sub-goal selection, lack of feedback on the value and importance of specific exercised towards the goals and health and wellbeing (Table 50).

LF5	Limitations of the Spirit50 application, if any?									
EX01	EX03	EX04	EX05	EX07	EX08	EX11	EX12	EX20	n	%age
	show graphs		show graphs			show graphs		show graphs	4	12%
limited onboarding				limited onboarding			limited onboarding	limited onboarding	4	12%
single health issue		single health issue				single health issue			3	9%

	show use of points				show use of points			show use of points	3	9%
feedback on value of exercises			feedback on value of exercises				feedback on value of exercises		3	9%
limited to single goal				limited to single goal					2	6%
weekly achievements							weekly achievements		2	6%
lacking socialization						lacking socialization			2	6%
add randomness				add randomness					2	6%
	not responsive						not responsive		2	6%
	add more quests					add more quests			2	6%
			more health details				more health details		2	6%
			add collaboration				add collaboration		2	6%
add unpredictability									1	3%
								Total	34	100%

Table 50: Limitations of Spirit50

They also noted the following limitations from the perspective of *extrinsic motivation*: lack of emphasis of the reward mechanism; the lack of the possibility of using rewards towards other quests and challenges; and a lack of clarity on progression versus time to goal achievement. Additionally, the lack of a social and collaborative environment was also noted as a downside of the app. From a resource perspective, non-portability to mobile devices such as tablets or smart phones could hinder the app because of older adults' preference to mobile devices in comparison to desktop/laptop environments.

Question LF6: *From the perspective of older adults, can you suggest ways to improve this application?*

Experts indicated that providing choices for sub-goal selection, variety of exercise routines, improved repeatability and memorability of the routines could help foster *autonomy*. Simplifying the interface design, mode of interaction (number of interaction steps), minimizing mouse clicks and dependence on a controller would help to reduce the need to remember steps, thereby allowing participants greater freedom and choice to do the routines (Table 51).

LF6	<i>From the perspective of older adults, can you suggest ways to improve the Spirit50 application?</i>									
EX01	EX03	EX04	EX05	EX07	EX08	EX11	EX12	EX20	Frequency	%age
	add more onboarding	add more onboarding		add more onboarding			add more onboarding	add more onboarding	5	17%
simplify app			simplify app			simplify app		simplify app	4	13%
	improve interface design		improve interface design				improve interface design	improve interface design	4	13%
			add usefulness of exercises	add usefulness of exercises		add usefulness of exercises			3	10%
add more choices					add more choices		add more choices		3	10%
		add responsiveness			add responsiveness	add responsiveness			3	10%
add benefits of routines			add benefits of routines						2	7%
				add feedback on form/gait				add feedback on form/gait	2	7%
	add value of rewards			add value of rewards					2	7%
		add overall workout plan				add overall workout plan			2	7%
								Total	30	100%

Table 51: Suggested Improvements for Spirit50

Showcasing the value of improvements, providing real-time feedback on exercises done, feedback on rewards and progression, constant encouragement through messaging and scaffolding of progress could help improve this app from its current format.

Question LF7: *Do you see any major hindrances in implementing Spirit50 application for older adults (over 50 years of age) in the context of Physical Activity and challenges caused due to aging?*

Experts indicated the challenges of older adults with technology adaptation, new terminologies, gamification elements and game design. Older adults' perception of games could be different from a gamification designers' perspective (Table 52). Therefore, the opportunity for education, training and onboarding of technology usage in a simple manner could go a long way in helping older adults adapt to this new way of facilitating PA motivation.

<i>Any major hindrances in implementing Spirit50 application for older adults in the context of PA and challenges caused due to aging?</i>											
LF7	EX01	EX03	EX04	EX05	EX07	EX08	EX11	EX12	EX20	Fre-quency	%age
older people and technology		older people and technology					older people and technology		older people and technology	4	19%
		interface design		interface design				interface design	interface design	4	19%
safety issues		safety issues						safety issues	safety issues	4	19%
			usability issues		usability issues			usability issues		3	14%
awareness of benefits				awareness of benefits				awareness of benefits		3	14%
						limitations of unsupervised activity			limitations of unsupervised activity	2	10%
							less patience			1	5%
									Total	21	100%

Table 52: Hindrances to the Implementation of Spirit50

In the same vein, instilling a feeling of safety when doing these exercises on their own, minimizing injuries during exercise without supervision, solving for challenges with balance and providing the confidence in their ability to do PA can improve the app.

Question LF8: *Do you see any usability challenges with this application in context of older adults (over 50 years of age) physical activity and challenges caused due to aging?*

Experts indicated that the main challenges for usability would be interface design, the lack of providing appreciable value of adapting to this site, and complex interaction routines between a modality when performing the exercises (Table 53).

<i>Do you see any usability challenges with this application in context of older adults' physical activity and challenges caused due to aging?</i>											
LF8	EX01	EX03	EX04	EX05	EX07	EX08	EX11	EX12	EX20	Frequency	%age
interfa ce design		interface design		interface design			interface design	interface design	interfa ce design	6	23%
			simplici ty of interacti on steps		simplicity of interaction steps	simplicity of interaction steps	simplicity of interaction steps	simplicit y of interacti on steps		5	19%
		onboardin g			onboardin g	onboardin g				3	12%
		explanatio n of the value of the app					explanatio n of the value of the app		explan ation of the value of the app	3	12%
			simplicit y of app	simplicit y of app		simplicity of app				3	12%
		feedback loop					feedback loop			2	8%
explan ations of icons								explanat ions of icons		2	8%
		explana tion of rewards		explana tion of rewards						2	8%
									Total	26	100%

Table 53: Usability Challenges to Implementing Spirit50

Additionally, a lack of coordination, balance and gait issues, lack of interest and boredom were also indicated to be characteristics that could lead to lower engagement by older adults. Experts also indicated that usability challenges could be mitigated by deploying such apps on tablets and smartphones that were easier to use.

Question LF9: *From an older adult’s perspective, do you think that the Spirit50 application could provide the opportunity of challenges and achievement in the form of exercise variations and/or levels of exercise intensities?*

Experts indicated that by providing challenges that facilitated increased autonomy, competence and mastery, the app could be a good and cost-effective, self-help tool for PA motivation.

<i>From an older adult’s perspective, do you think that the Spirit50 application could provide the opportunity of challenges and achievement in the form of exercise variations and/or levels of exercise intensities?</i>											
LF9	EX01	EX03	EX04	EX05	EX07	EX08	EX11	EX12	EX20	Frequency	%age
		meaningfulness to users		meaningfulness to users		meaningfulness to users	meaningfulness to users			4	14%
		mindful of health issues		mindful of health issues			mindful of health issues		mindful of health issues	4	14%
	in-creased choice					in-creased choice			increase d choice	3	11%
		onboardi ng			onboardin g	onboardi ng				3	11%
	opportu nity for compe- tence						opportu nity for compe- tence		opportu nity for compe- tence	3	11%
	enable mastery			enable mastery				enable mastery		3	11%
	increase d options			in-creased options						2	7%
		increase d difficult y levels			increased difficulty levels					2	7%
			in-crease d chal- lenges					in-creased chal- lenges		2	7%
			incorp orate safety					Incorp orate safety		2	7%
									Total	28	100%

Table 54: Opportunities of the Spirit50 app

They also indicated that variety of exercises and increased difficulty could lead to increased engagement. Existing gamification elements could be improved to provide greater value of rewards mechanisms and display of progression information. Being cognizant of the potential of injuries and physical limitations of older adults should influence the types and intensities of exercises being recommended. The app could foster healthy living and wellbeing provided that

onboarding of new technology could be provided. Increased portability of the app by designing it to work on mobile devices like tablets and smartphones could help to increase acceptance of the app with older adults.

9.4.2 Quantitative Analysis

Scale Reliability

All 17 dimensions of the HEG (Tondello, Kappen, et al., 2016) had high reliabilities, Cronbach's $\alpha = .94$. The sub-scales also indicated high reliability with deleted items which are shown in Appendix 13.11.4. Data were normal based on the Kolmogorov-Smirnov test,

Correlations

Bivariate correlation was tested between each sub-scale using Pearson's r . Effect sizes are reported in terms of small effect ($r = .10$), medium effect ($r = .30$) and large effect ($r = .50$) (Field, 2013). Results (Appendix 13.11.5) show significant high correlations for the intrinsic motivation sub-scales between *Autonomy-Creativity* and *Challenge-Competence* ($r = .708, p < .05$), and *Completeness-Mastery* ($r = .812, p < .05$); *Relatedness* and *Completeness-Mastery* ($r = .851, p < .05$); *Immersion* and *Completeness-Mastery* ($r = .675, p < .05$).

For sub-scales from extrinsic motivation, large effect was seen between *Ownership* and *Completeness-Mastery* ($r = .685, p < .05$); large effect was indicated between *Rewards* and *Completeness-Mastery* ($r = .942, p < .01$), *Autonomy-Creativity* ($r = .851, p < .01$), *Relatedness* ($r = .698, p < .01$), *Immersion* ($r = .721, p < .05$) and *Ownership* ($r = .767, p < .01$). Large effect was also seen between *Virtual Economy* and *Relatedness* ($r = .858, p < .01$).

For sub-scales from the context dependent dimension, large effect was indicated between *Feedback* and *Completeness-Mastery* ($r = .700, p < .05$), *Autonomy-Creativity* ($r = .793, p < .05$), and *Rewards* ($r = .817, p < .01$); *Actionable Feedback* and *Immersion* ($r = .807, p < .05$). Furthermore, medium effect was seen between *Graspable Progress* and *Autonomy-Creativity* ($r = .696, p < .05$); *Feedback* ($r = .767, p < .05$) and *Actionable Feedback* ($r = .673, p < .05$); large effect between *Unpredictability* and *Relatedness* ($r = .712, p < .05$), *Scarcity* ($r = .789, p < .05$) and *Graspable Progress* ($r = .780, p < .05$). Additionally, there was large effect seen for

Disruption Control and Ownership ($r = .682, p < .05$); and large effect for *Innovation and Loss Avoidance* ($r = .674, p < .05$).

Usefulness, Easiness and Clarity

The expert evaluation indicated that Spirit50 was favourable from a usefulness and ease of use perspective (Appendix 13.11.6). However, there was a consensus among the experts that the web application needed more clarity in the interface design to provide greater ease of use to older adults.

9.5 Discussion

In this chapter, experts evaluated motivational affordances for PA technology using the long form questions and HEG (Tondello, Kappen, et al., 2016). This was done using Spirit50 as an example of PA technology for older adults, which was evaluated for its applicability, usefulness and ease of use of the application. The evaluation was done using long form interview questions and HEG (Tondello, Kappen, et al., 2016). Consistency in findings from the expert evaluations presented through QCA and HEG highlighted Spirit50 as an application for facilitating PA had its advantages and limitations.

9.5.1 Qualitative and Quantitative Results

Qualitative Analysis: Overall experts' feedback regarding the applicability and usefulness of the Spirit50 app were positive. The QCA analysis (Table 46 - Table 54) provided details of various aspects of the applicability of motivational affordances (gamification elements) for PA technology for the older adults' demographic. The experts' responses to long form questions indicated that certain intrinsic gamification elements such as goals (19%) and achievements (10%) could be given higher importance than elements such as competence (6%) and mastery (6%) (Table 46). It is possible that the presence of PA goals and the successful completion of these goals provided a sense of achievement for older adults fostering intrinsic motivation, whereas competence depended on the ability of older adults to perform certain activities. This is similar to the findings by from a prior study where self-driven goals foster achievement leading to satisfaction in older adults (Chen et al., 2014; Romero et al., 2010). Experts indicated that

points (13%) progress bars (2%) and stars (2%) as extrinsic motivation elements had its place in providing relevance of effort towards a PA.

While gamification elements such as challenges (12%), goals (10%) facilitated the competence dimension, the elements such as choice (10%) and ability (8%) were impactful elements (Table 47) that fostered the autonomy dimension of the SDT (Boulos & Yang, 2013; Zuckerman & Gal-Oz, 2014). This shows that competence and autonomy are important dimensions within the context of PA for older adults (Edmunds et al., 2006; Stathi et al., 2014). While the importance of feedback elements such as progress bar (21%), points 15%, stars (13%), and completion status (13%) (Table 48) within the Spirit50 app contributed to older adults PA, experts indicated that providing intermittent feedback in areas such as, correctness of form (16%), challenge types (14%), value of exercises (11%), and performance feedback (11%) (Table 49) could help to make the PA technology more helpful than its current design. This feedback is similar to prior studies that indicated that older adults needed feedback as a means of reassurance of the correctness of steps and body orientation (Kappen et al., 2016; L. E. Nacke, Nacke, & Lindley, 2009).

Experts' responses indicated that feedback to older adults would be better if it provided feedback in a graphical format (12%) with step by step training on app usage (12%) and benefits (value) of exercises (9%). Furthermore, the flexibility of app to sustain multiple health goals (9%) and improved socialization (6%) could help with improving the app (Table 50, Table 51). This would facilitate better interaction due to visual feedback (Bobeth et al., 2012; Marston, 2013) and onboarding (Deterding, 2013; Larsson, 2013b; Miller, Cafazzo, & Seto, 2014; Silva et al., 2014).

Barriers to entry to using PA technology also stems from the reluctance of older adults to use technology (19%), interface issues (19%), safety issues (19%) and interaction issues (14%) (Table 52). This is also similar to findings from prior studies that older adults inhibitions and attitudes towards technology is a challenge and could be overcome through playful persuasion (Brauner et al., 2013; Grönvall & Verdezoto, 2013; Nigg, 2003; Pereira et al., 2014).

Incorporating iterative interface design principles geared towards older adults' visual limitations (23%), being cognisant of the need for simplicity of steps (19%) and ease of use of the app (12%) (Table 53) were important to overcome usability challenges of older adults with PA technology (Ijsselsteijn et al., 2007; Jung et al., 2009a; Motti & Vigouroux, 2013; Siriaraya et al., 2012). At the same time, being mindful of individual health challenges (14%), increased choice (11%), tailoring the app to foster competence (11%) and mastery (11%) and increased difficulty levels (7%) (Table 54) enabled Spirit50 to be a PA technology that provided goal-based challenges to the older adult demographic. These responses from experts suggest that PA technology using gamification elements were important for older adults in the context of their physical and age-related infirmities (Ronald M Baecker et al., 2012; Belchior et al., 2012; Gerling, Schulte, et al., 2011; Kuroda et al., 2012). While Spirit50 is a step in the right direction, care must be taken to ensure that onboarding and the safety issues of self-monitored PA (Grönvall & Verdezoto, 2013; Nigg, 2003) are considered when designing such technology.

Quantitative Analysis: Quantitative analysis of the HEP questionnaire indicated significant positive correlations between many dimensions within the three categories of intrinsic, extrinsic and context-dependent heuristics (Tondello, Kappen, et al., 2016). Details of these dimensions are provided in (Table 55) and significance values are provided in the appendix (13.11.5).

Intrinsic motivation	Extrinsic Motivation	Context-dependent
Autonomy - Creativity and Challenge - Competence	Ownership and Completeness - Mastery	Feedback and Completeness - Mastery
Autonomy - Creativity and Completeness - Mastery	Rewards and Completeness - Mastery	Feedback and Autonomy-Creativity
Relatedness and Completeness - Mastery	Rewards and Autonomy - Creativity	Feedback and Rewards
Immersion and Completeness - Mastery	Rewards and Relatedness	Actionable Feedback and Immersion
	Rewards and Immersion	Graspable Progress and Autonomy - Creativity
	Rewards and Ownership	Graspable Progress and Feedback
	Virtual Economy and Relatedness	Graspable Progress and Actionable Feedback
		Unpredictability and Relatedness
		Unpredictability and Scarcity
		Unpredictability and Graspable Progress
		Disruption Control and Ownership
		Innovation and Loss Avoidance

Table 55: Significant Correlations of Dimensions within the HEP categories (Tondello, Kappen, et al., 2016)

Within the **intrinsic motivation** heuristics, correlation between *Autonomy - Creativity and Challenge – Competence* dimensions indicated that the app provided users the freedom to choose their vague-goals (long-term goals) and specific goals in relation to their health conditions. These specific goals output exercise routines that were adjusted in the difficulty level to the ability of the user (Tondello, Kappen, et al., 2016). Positive correlation between *Autonomy - Creativity and Completeness – Mastery* indicated that while users had the choice to select their long-term goals and specific goals, the difficulty level of the exercise routines increased progressively each week. The app also enabled users to keep track of their completed tasks (Tondello, Kappen, et al., 2016). While the app did not have an PA sharing button with others to build a community, significant correlation in the *Relatedness and Completeness -Mastery* dimension indicated that the app afforded the possibility to compare themselves with the exercise metric, provided a balanced and fair system (Tondello, Kappen, et al., 2016), and had the potential to include comparison with others. Positive correlation between the *Immersion and Completeness -Mastery* dimensions indicated that the app provided the aspect of engagement with the exercise routines as an aesthetic and physical experience while providing the environment for improvement of skills through repetitious routines with increasing difficulty levels (Tondello, Kappen, et al., 2016).

Within the **extrinsic motivation** heuristics, positive correlation between *Ownership and Completeness -Mastery, Rewards and Completeness -Mastery and Rewards and Autonomy - Creativity* indicated that while the system afforded the possibility to own virtual goods (points and stars), the achievement of these virtual goods was based on the completion of specific tasks of increasing difficulty, freedom of selection of tasks based on individual ability and health conditions, which in turn was a meaningful process of acquisition of such virtual goods (Tondello, Kappen, et al., 2016). The rewards were proportional to the time and effort put into doing the PA routines on a daily and weekly basis. Significant correlation between *Rewards and Relatedness* indicated that the app facilitated a balanced and fair acquisition of rewards (Tondello, Kappen, et al., 2016) that could be used for self-monitoring of daily and weekly targets for comparison with others. In the same manner, the correlation between *Rewards and Immersion* indicated the rewards within the app facilitated meaningful interaction with the health story (in the app) and enabled the collection of rewards as a validation of effort and continued

engagement in the system. Correlation between *Virtual Economy and Relatedness* indicated that the app facilitated the collection of rewards (points and stars) for task completion and indicated progression within the system on the progress bars. While there was no exchange of rewards with others within the app, the app facilitated the possibility of these rewards to be communicated with friends and peers outside the system.

Within the **context dependent** heuristics, positive correlation *between Feedback and Completeness -Mastery, Feedback and Autonomy-Creativity, Feedback and Rewards* indicated that the system communicated the completion of tasks and achievements', facilitated the selection of goals and sub-goals, and provided collections of rewards for reaching set targets within daily/weekly routines respectively. Correlation between *Actionable Feedback and Immersion* indicated that system provided information of the exercise routines to follow which enabled continued engagement with the system. At the same time, a significant positive correlation between *Graspable Progress and Autonomy – Creativity* indicated that the system indicated users' progression (Tondello, Kappen, et al., 2016) and a roadmap for future weeks and the choice of selection of the order in which the exercises and routines could be done. For the correlations between *Graspable Progress and Actionable Feedback*, and *Graspable Progress and Feedback*, the app indicated the availability of a roadmap for progression in comparison to their current position in the entire fitness plan and provided the next steps for further improvements respectively. Correlations between *Unpredictability and Relatedness*, *Unpredictability and Scarcity*, and *Unpredictability and Graspable Progress*; the app provided intermittent tasks which were random tasks to break the routine nature of the exercise roadmap; allowed for collecting stars and points with no rewards for inaction, and varied rewards for different types of activities respectively. Significant correlations between *Disruption Control and Ownership*, and *Innovation and Loss Avoidance* indicated that the system is protected against cheating (Tondello, Kappen, et al., 2016), and allowed users to contribute ideas for exercise routines, specific goals and health challenges respectively. These attributes led to the following discussion on motivational affordances for older adults PA technology.

9.5.2 Motivational Affordances and Older Adults PA

Based on the QCA, experts indicated that *autonomy* can be fostered by giving older adults the opportunity to do manageable and achievable PA activities in the app. Helping them to feel in

charge of their health through PA can be engendered by helping them to achieve sub-goals such as: improving mobility in arms, legs and further leading to a full body mobility. These sub-goal selections could allow selection of the type of exercise (strength, endurance and flexibility), the type of intensity (low, medium and hard) and these could be set up as choices in the app, allowing them to take ownership of their decisions leading to self-regulation.

Competence can be fostered by providing the opportunity to level-up, by allowing older adults to complete levels of exercise which are increasing in difficulty level and in exercise intensity. The possibility of creating achievement levels based on this increasing or decreasing intensity will allow them to achieve mastery of their sub-goals leading to a better feeling of accomplishment. While providing older adults the opportunity to succeed in an incremental manner is important, it is also critical to be aware of the possibility of boredom which could set in due to the simplicity of routines. Therefore, surprising them with spontaneous or random difficult challenge could help to add to the element of curiosity and the need for a sudden burst of energy to do the prescribed challenge.

Relatedness can be fostered through their desire to share their effort and success in completion of tasks with others. While older adults may have challenges with technology adoption during the initial phase of being introduced to a gamified app, the portability of having the technology on their smartphone or tablets allows for easier access to the routines. This aspect, when combined with the possibility of reviewing the correctness of the exercise routines many times over using technology, adds value to the gamified technology

Rewarding effort, as opposed to task completion, is an interesting attribute that could be considered as *extrinsic* motivators. This would serve as a form of praise being introduced intermittently during the course of the program. This would provide older adults with the reassurance that they are on the right track and allow them to understand that they were meeting certain milestones in the exercise program. In this manner, the app would work in the same manner as a physical trainer providing feedback for improvement. Ideally, the potential of detecting incorrect posture and correctness of body position in an exercise routine would provide real-time feedback for improvement. However, this would necessitate additional reliance on

technology needing real-time tracking of body movements with additional cameras. Rewards also help to provide validation of efforts and serves as achievement markers.

9.5.3 Advantages of Spirit50

Intrinsic motivation

The findings from QCA showed that experts valued the Spirit50 app to be one way to facilitate PA amongst older adults. The applications usage of gamification elements like goals (quests), challenges, and routine activity would help foster intrinsic motivation among older adults from the perspective of improving their health and wellbeing. It also provided the platform for habit formation leading to continued voluntary usage of the app or the exercise routines anywhere and everywhere. The simplicity of the app routines helped with easily remembering the routines from the app. The choice of selection of vague goals (long-term goals) and specific goals (short-term goals) and input of barriers and current health conditions afforded *autonomy* among the users.

Competence at doing the routines and ability to meet goals were also subtle affordances facilitating older adults to perform better at simple tasks which increased in intensity as the weeks progressed. Enabling older adults to achieve task completion within the app also fostered competence. This would provide them with the feeling of being capable of doing the tasks assigned to them on a daily basis.

The correlations between *autonomy-creativity*, and *challenge-competence*, and *completeness-mastery* in the quantitative analysis of the HEG indicated that the system provided users with the choice of selecting their goals with multiple paths to achieve the same result (Tondello, Kappen, et al., 2016). This also indicated that the challenges presented in Spirit50 were presented as motivations for PA, adjusted to users ability and new goals were presented on completion of existing goals (Tondello, Kappen, et al., 2016).

Extrinsic Motivation

Experts valued the presence of points and stars as the only extrinsic reward mechanisms present in the application. Progression on daily challenges served to be a marker for the users to gauge their progress along the program. Experts acknowledged the rewards to be a way of recognizing

accomplishment or achievement of levels. These, in turn, seemed to work in the form of virtual praise for task completion.

Correlations between *Ownership* and *Challenge-Competence*, *Completeness-Mastery* from the quantitative analysis of HEG indicated that Spirit50 enabled users to set up their own profile. Progression is based on virtual goods and foster challenge and mastery of specific exercise routines. Furthermore, correlations between *Rewards* and *Challenge-Competence*, *Completeness-Mastery*, *Autonomy-Creativity* shows that Spirit50 afforded possibilities of rewarding the user for continued usage of the system, completing tasks and being meaningful to the user.

Feedback Options

Experts indicated relevance of the feedback provided by the app which indicated number of reps and steps completed, goal selection and daily fitness roadmap, completion of tasks and visual representation of their progression through a progress bar. While the app provided many exercise routines for the three exercise types (endurance, flexibility and strength training), experts considered the value of the flexibility exercise routines that were explored by them from the point of simplicity of task completion and reaching small goals. Simplicity of the exercises and the ease of remembering the routines provided greater value from a memorability perspective.

Correlations in the context dependent dimension in the HEG between *Feedback* and *Completeness-Mastery*, *Autonomy-Creativity* showed that the system provided users with feedback based on completeness of tasks and availability of new exercise routines to be done within the roadmap. It is also interesting to note that the availability of new exercise routines can be construed as an opportunity to facilitate choice of doing the routines while presenting an element of unpredictability in the gamification system.

9.5.4 Limitations of Spirit50

Intrinsic Motivation

Social interaction and community formation were not fostered though the app, which the experts felt were limitations to the app for PA facilitation. This is because engendering the process of interacting with others creates collaborative sharing of experiences and affords *relatedness*. This

would help foster the feeling of togetherness and help overcome the feeling of loneliness among older adults.

Providing a performance mapping or rating from a correctness perspective is important so that users would understand that they are doing the routines correctly. Incorporating such features would help to provide real-time feedback to the users and foster *competence*.

The Spirit50 provided a constant routine with small changes on a weekly basis. This was a limitation because interest and curiosity could be engendered by the app by providing new and random routines and surprise elements. At the same time, providing greater options for users to make changes in their pre-defined routines, such as increasing exercise intensity or difficulty level, and providing them with the choice of sub-goals selection would help to foster greater *autonomy*.

Extrinsic Motivation

The location and the sizing of the points, stars and progression icons were quite small in size. This could be accommodated by allowing for increased visibility by changing color intensity and sizes that could be changed by the user. Furthermore, this became a challenge in that these affordances risked being overlooked by the user. Accomplishing a set of challenges is an achievement and must be flaunted on the interface design which was not done effectively. Correct location of these visual cues and emphasizing the design of these elements could increase the motivation of the participants to do more, and do better. Presenting a time to completion option in a graphical format would help older adults to quickly relate their current level relative to the levels yet to be done to complete their goal (quest).

Feedback Options

While characteristics of the app indicated feedback from the point of number of reps and steps completed, progression towards goals selected on a daily basis, there was limited real-time feedback regarding the correctness of the posture. Older adults tend to take more time in understanding the steps presented to them on the screen and often take more time in actually doing the routines. This coupled with the challenge of understanding the routines and performing

the routines could pose an additional cognitive load for older adults. Therefore, the possibility of slowing down the video description of the exercise routine could be provided.

Older adults are also more critical when asked to do exercise routines in a specific manner because they may be set in their own ways of interpreting and doing things in a certain manner. Therefore, explanations of the value and importance of the specific exercises could be provided so that they are convinced about the potential benefits of doing any of the routines. Explanations could be provided in a graphical illustrative format or textual format.

There would also be challenges with handling the mouse and the desktop because of their limited dexterity. This could be overcome by providing pointing tools or assistive touch screen options on a tablet. Understanding older adults' conceptualization of games and gamification is also critical because this would allow designers to either design to their expectation or provide education and onboarding modules to help them get comfortable with terminologies and technology deployment parameters.

From the quantitative analysis of the HEG, the aspect of users being able to fake the system by clicking on the start-stop timer buttons led to challenges with disruption control and loss avoidance (Tondello, Kappen, et al., 2016) within the system. This could also mean that incorporating timed tasks could be interesting, however, the ability of older adults to perform a timed exercise routine would have to be investigated first so that their inability to complete a task on time would not lead to a feeling of incompetence. If not, it could be frustrating for older adults because of the limitations in their physical ability to complete timed tasks. This means that it would be better if the system would provide reachable targets from a timing perspective, but also provide users the opportunity to change or reduce the timing of the challenges while providing the choice to increase the difficulty or challenge level of the exercise routines

Usability

Older adults lack of coordination, fear of falling, balance and stability issues also pose a greater challenge in providing a safe and enjoyable gamification platform to facilitate PA. While younger adults may have the capacity and capability to do exercises with some element of safety

in mind, the above challenges pose questions on providing safe and non-supervised exercise routines for older adults. This may also be the reason for the numerous apps for walking with motivational affordances, because of the simplistic nature of the walk activity in comparison to exercise routines.

9.6 Summary

Gamification has been used by many researchers and designers to increase motivation and engagement of users in a given activity (Juho Hamari, 2015; Juho Hamari & Koivisto, 2015a, 2015b; Lister et al., 2014; Richards, Thompson, & Graham, 2014; Seaborn & Fels, 2014). This chapter demonstrated through an expert evaluation the purposefulness of motivational affordances through gamified technology, its applicability, usefulness, and ease of use of Spirit50. The expert evaluation used long-form questionnaires and the HEG (Tondello, Kappen, et al., 2016), a gamification toolkit to evaluate Spirit50 from a PA gamified technology perspective. Spirit50 was PA technology that was specifically designed for older adults PA using gamification elements (motivational affordances). This technology used SDT (Boulos & Yang, 2013; Zuckerman & Gal-Oz, 2014) and the KEG (Kappen & Nacke, 2013) model for its design and development. Experts indicated that Spirit50 was a step in the right direction with the introduction of motivational affordances facilitating intrinsic and extrinsic motivation to increase the engagement of older adults to participate in PA. QCA and quantitative analysis of the expert evaluation indicated that gamification elements contributed to fostering intrinsic motivation among older adults because it afforded PA through the use of gamification elements like goals (quests), challenges, achievements, and task completion of specific exercise routines on a daily basis leading to an eight-week fitness program. These elements afforded the possibility of feeling of competence and accomplishment based on task completion and increased difficulty levels of exercise routines. Extrinsic motivation was facilitated through reward mechanisms in the form of points, stars and progression metrics for task completion. While Spirit50 fostered intrinsic and extrinsic motivation in older adults for PA, experts suggested the addition of sub-goals, graphical progression meters, collaborative community building and deployment of the design on mobile devices such as smartphones and tablets, would facilitate autonomy, relatedness and increased portability respectively. This would also improve engagement in PA among older adults. Experts

also indicated modulating the design to consider non-supervised interaction of older adults with the PA technology from a convenience and safety point of view. Experts were also concerned about the perception/misconception of older adults about games and gamification elements and the need to educate and create onboarding opportunities to help them be comfortable with PA technology.

Chapter 10

10 Thesis Discussion

Throughout this research, the focus has been to identify intrinsic and extrinsic motivational affordances for fostering PA through technology among older adults. This dissertation has progressively established that tailoring motivational affordances (gamification elements) for older adults will help to customize and personalize gamified technology (Chapter 6, Chapter 7, Chapter 8, Chapter 9) for older adults. This chapter discusses the findings and contributions from the five phases of this dissertation.

10.1 Impact of Designing Adaptive Engagement PA Systems

Health tracking and gamification of physical exercise are on the brink of becoming part of our daily routines. For instance, Apple has just released a new mobile operating system with a health tracking app (compatible with a smart watch capable of everyday physiological data tracking). Similarly, other wearable solutions like Fitbit (“FitBit,” 2015) and Nike+ FuelBand (“Nike+ FuelBand,” 2014) are becoming available for the mass market. Online health tracking websites have seen an increase in uptake with solutions like Fitocracy (“Fitocracy,” 2015), FitOrbit (“FitOrbit,” 2015), UtiliFit (“UtiliFit,” 2015), Fleetly (“Fleetly,” 2015) and Mindbloom (“Mindbloom,” 2015) to mention a few. However, a range of challenges with these wearable and online applications such as interface design, usability and interaction touchpoints, and physical exercise routines are generalized for a generic population (van Mierlo et al., 2016) and not specifically tailored towards the exercise motivations of older adults. The presumption by commercial enterprises that the design of these applications in a one size fits all approach format and universal adaptation for all target markets is flawed. This thesis provides detailed investigation on intrinsic and extrinsic motivational affordances that could help tailor technology for the older adult demographic.

This thesis investigated using gamification elements as a strategy for customizing and personalizing PA technology for older adults. The term *adaptive* may have multiple meanings in

computer science. In the context of this thesis, *adaptive* indicates the flexibility of the online application to be customized to users' goals, motivations, challenges, barriers, and current health (Geurts et al., 2011; Smeddinck et al., 2013). The five phases of this investigation emphasised the understanding of the specific needs and wants of older adults from a PA perspective. Motivation for PA is facilitated by intrinsic and extrinsic motivations. This thesis provides new insights for implementing motivational affordances in PA technology (Figure 43) by using gamification strategies to increase enjoyment and tailor engagement of older adults when engaged in PA.

A systematic review on older adults preferences for participation in PA found six themes which were: social influences, physical limitations, competing priorities, access difficulties, personal benefits, and motivation and beliefs (Franco et al., 2015). These themes which are closely related to the motivation of older adults for PA, differentiated into intrinsic and extrinsic factors can be fostered through technology (Section 8.6 and Figure 43). These findings extend the knowledge about PA motivation among older adults into additional relevant themes from a gamified technology investigation.

I designed the KEG (Kappen & Nacke, 2013), a design and analytical tool for designing gamification systems fostering intrinsic and extrinsic motivations while serving as a behaviour change mechanism. Phase 1 of this investigation – presented in Chapter 5 – used this design framework as an analytical tool to analyze preliminary interviews. I conducted focus group sessions with older adults and physical trainers about PA motivation. I analyzed findings from this phase, which resulted in design strategies for gamified PA of older adults PA (Kappen et al., 2016) and the EMTF. I conducted a survey study on motivational affordances differentiated by age-groups to investigate preferences of gamification elements and feedback elements – presented in Chapter 6 (Phase 2). In Phase 3, I used the KEG, design strategies for gamified PA, and the EMTF, as a design tool and co-developed Spirit50. This was a gamification application with a few select gamification elements, tailored for PA motivation among older adults over 50 years of age – presented in Chapter 7. I then investigated PA motivation of older adults (over 50 years of age) through an eight-week experimental study (Phase 4) where 30 participants were randomized into three groups: gamified, non-gamified, and control group (Chapter 8). This study

investigated the potential of gamification as a strategy to increase user enjoyment and engagement in an activity as mundane as daily exercise. Finally, I conducted an expert evaluation of Spirit50, the gamification artifact designed for older adults – presented in Chapter 9 (Phase 5).

In this chapter, I discuss key findings of this thesis from these five phases promoting gamification technology as a behaviour change mechanism for PA motivation of older adults.

10.2 Summary of Findings and Takeaways

The key findings I gathered from the five phases of my PhD research highlights the potential of designing technology-facilitated engagement on an adaptive basis. In this section, I summarize key findings and contributions from each phase.

Phase 1: Chapter 5

Findings

These findings were published in conference proceedings (Kappen et al., 2016)

- PA motivation was categorised into long-term goals (vague-goals) and short-term goals (specific goals), barriers for PA, and current health conditions based on thematic analysis of qualitative data using SDT and KEG.
- Fear of age-related changes, physical impairments, and feeling of being unable to do daily PA or exercise routines was a motivator to do PA.
- Engagement in PA can be improved based on defining the purpose of the exercise routines, customization of exercise routines, independence and ability to do the routines.
- Accountability, staying on track and social validation, were key characteristics that helped foster intrinsic motivation for PA.
- While needs and wants are specific to demographics under consideration, age-related physical limitations and impairments indicated micro-level differentiation of older adults PA motivation as discussed in the design strategies for gamified PA (Kappen et al., 2016).
- Extrinsic (tangible) and intangible rewards helped to foster PA motivation.

Takeaways

- Detailed categorization of needs and wants of older adults PA motivation enabled the design of the Exercise Motivation Technology Framework (EMTF), specific to gamified PA technology.
- Cognisance of abilities, customization and personalization of motivational affordances such as goals, exercise challenges, monitoring progression and rewards formed the initial design strategies for adaptive engagement.

Phase 2: Chapter 6

Findings

- This study indicated that health pressures and ill-health avoidance were significant motivations that influenced participation in PA in the age groups compared.
- Findings from this study identified differentiation between gamified motivational elements (are goals, challenges, progression, achievements, choice quests, and social sharing) and feedback elements (including calorie tracking, step counters, distance travelled, daily notifications, time spent, heart rate, breathing rate, speed, sleep cycle, sound inputs and weight loss indicators) (Section 6.6.1).
- Findings indicated differences in motivational affordances preferred by the four different age groups (Section 6.4.2.2). This differentiation indicated that older adults (65+) preferred more spontaneous feedback, simplicity of challenges, and ease of remembering steps while earning badges. Addition of progression elements, comparison with PA milestones and opportunity to modulate goals were specific motivational affordances to the group in the 50-64 age category.

Takeaways

- This work provided new insights to differentiating motivational affordances to be tailored for different age groups, with the goal of helping researchers and designers to better understand design challenges when creating PA applications for different age groups. This is an important step in the development of age-differentiated meaningful health technology applications for adults, young and old.

- Age-differentiated customization and personalization of motivational affordances would allow designers and researchers to design more engaging experiences (Boyle et al., 2012; Mekler et al., 2014) while applying gamified technology in the initiation, maintenance and adherence of PA that promote physical and mental well-being.
- Results suggested that people in different age groups have different preferences regarding motivational affordances, which led to the design of age-group-specific guidelines for incorporating motivational affordances in PA technology (Section 6.6).

Phase 3: Chapter 7

Findings

- A usability study showed the challenges related to handling the mouse, having to watch exercise on the screen and also be expected to be coordinated to do the exercise. Preferred locations of the navigation buttons and location of images were a result of the study.
- Many older adult participants indicated that instant gratification was not important.
- Findings also showed that receiving praise, being commended for their performance by their PT, and earning bragging rights for capability in performing fitness activities fueled self-determined extrinsic motivation.

Takeaways

- Interaction study of Spirit50 helped to understand the challenges faced by the users regarding terminologies used in the application.
- Helped to identify expectations of the user from their perception of usage and the actual work flow of the application.
- Need for instant gratification as a tangible visible reward was not as important for older adults when compared with teenagers or younger adults.
- Lessons learned provided key directions to redesign the Spirot50 artifact for beta testing.

Phase 4: Chapter 8

Findings

- Findings from qualitative analysis indicated that the gamified group showed more engagement and interest in performing PA facilitated by technology over an eight-week period.
- From the PNSE: Perceived competence, perceived autonomy and perceived relatedness was higher in the gamified group than the non-gamified and control group.
- From the IMI: Significant trend in the data was seen toward the gamified group in the following dimensions: Interest/Enjoyment, Perceived Competence, Effort/Importance, Perceived Choice, Value/Usefulness
- From RPE: Participants in the gamified group (Group 1) felt lower exertion compared to the participants from the control group (Group 3).
- Quantitative analysis indicated significant increase in the perceived competence dimension compared to the non-gamified and the control group.
- Increase in autonomy and competence was indicated with the usage of gamification elements.
- Enjoyment and engagement increased with the use of gamification elements in PA technology.

Takeaways

- Findings indicated congruence between qualitative and quantitative data analysis where within the constructs of motivation posited by SDT
- The gamified group participants showed interest and enjoyment through improving on deficiencies, increasing challenges progressively; indicated perceived competence through increasing challenges progressively, feeling of the ability to do more and increasing difficulty levels; feeling importance of effort/importance by feeling validated for their efforts, measuring progress and improvement in body conditioning.
- The non-gamified group showed an interest in quantification metrics such as increased daily step count, increased challenges in their routine walking such as adding hiking trails, hills and valleys and rough terrain, and longer walk durations.

Phase 5: Chapter 9

Findings

- Experts indicated fostering intrinsic and extrinsic motivation to increase the engagement of older adults to participate in PA.
- QCA and quantitative analysis of the expert evaluation indicated that gamification elements contributed to fostering intrinsic motivation amongst older adults because it afforded PA through the usage of gamification elements like goals (quests), challenges, achievements and task completion specific exercise routines on a daily basis leading to an eight-week fitness program.
- From the perspective of gamification of PA technology, experts suggested the addition of sub-goals, graphical progression meters, collaborative community building, and deployment of the design on mobile devices such as smartphones and tablets for facilitating autonomy, relatedness, and increased portability respectively for older adults PA.

Takeaways

- Expert evaluation showed that motivational affordances through gamified technology can serve as triggers for older adults
- Expert evaluation showed the applicability, and usefulness, of the Spirit50, a gamification artifact.

10.3 Revised EMTF Model

Based on the findings from the five phases, especially the findings from the experimental study (Phase 4) and the expert evaluation (Phase 5) the original EMTF can be extended to include desirability of an app (motivation within the target demographic), customization (designing to ability), and motivational affordances (Figure 44).

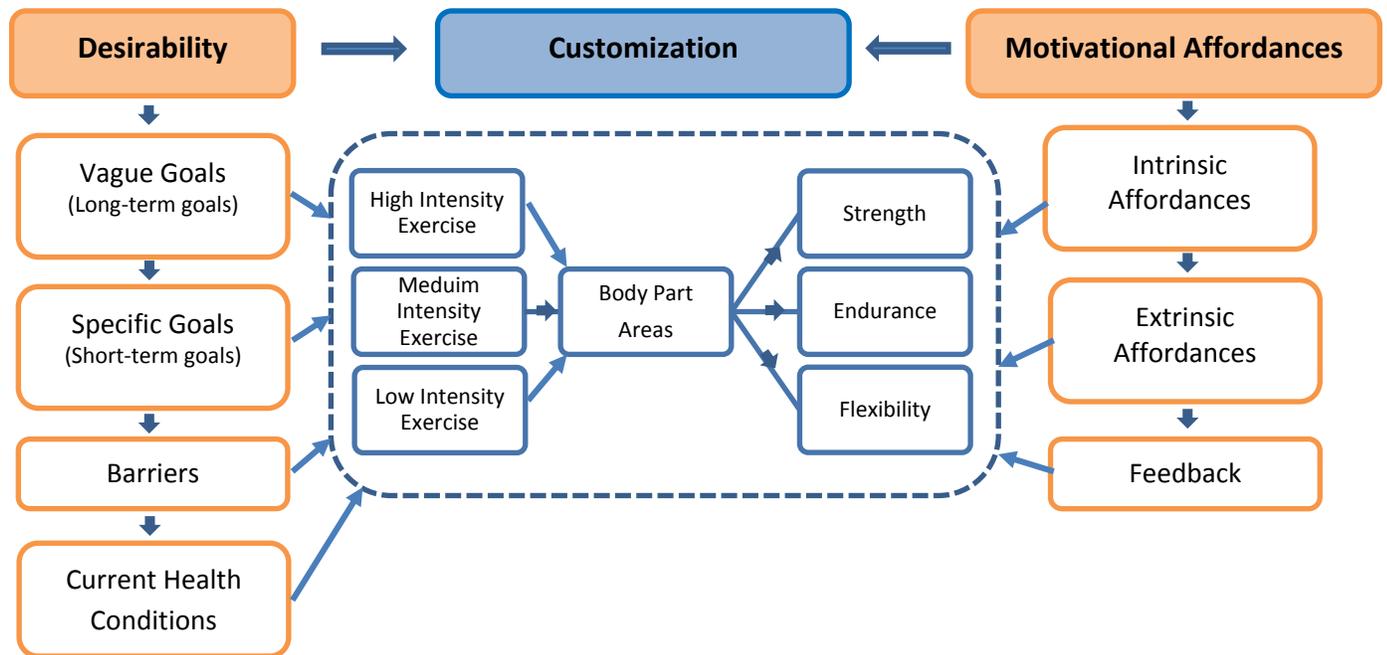


Figure 44: Revised EMTF Model

10.4 Implications of Designing Gamified PA Technology for Older Adults

Based on the findings from the five phases, motivational affordances can be deployed in gamification strategies for PA technology for older adults. This thesis indicates detailed motivation elements for PA from the older adults' perspective. Qualitative analysis using thematic analysis (Section 8.6) showed that the facilitation of PA depends on various factors such as: motivation to participate in PA, setting up of goals for PA, feeling of accomplishment of goals, fears, and barriers to PA, and rewards and tracking mechanisms. Intrinsic motivation attributes such as feeling good, feeling of accomplishment, satisfaction of doing the routines, confidence in ability to initiate the task of participating in exercise routines contributes towards habit formation and can lead to adherence and maintenance of regular physical activity. While being rewarded in the form of badges, points, experience points, and scores are a few examples of tangible rewards, the improvement in appearance, weight loss, and better-looking skin are also examples of tangible rewards. Intangible rewards can range from accomplishments of feeling good, feeling energetic, praise, recognition, and improved confidence in ability to regulate one's healthy behaviour to mention a few. Praise, reassurance and recognition of effort from coaches on a real-time basis (Section 5.3.1.2) and virtual trainers (Section 8.6.1) provided rewards to

facilitate increased participation in PA. Motivational affordances provided by gamification technology assists with remembering to do the exercise routines, quantifying physical activity metrics through tracking steps, and providing feedback on calorie intake and calories burned throughout daily activities thereby fostering a sense of accomplishment. As seen from sports and exercise contexts, extrinsic rewards also help to foster intrinsic motivation by providing the drive to improve performance, reach new levels of achievement and even inspire users to do more workouts (Cho, Jun, & Cho, 2002; Larsson, 2013b). Furthermore, social influence attributes of reciprocal recognition, sharing of physical activity content, likes and promotion of shared goals help with sustaining physical activity and committing to exercise routines through a community platform. This helps with building confidence in an individual and overcoming the feeling that they are not alone in overcoming obesity, sedentariness, or having low energy.

As shown in the evidential chain from qualitative analysis (Figure 43), these factors can be facilitated through gamification by the application of motivational affordances. Design implications for the deployment of gamified PA technology for older adults are as follows:

Engaging Experiences by Fostering Interactions: Findings from phases of this project showed that older adults preferred a combination of indoor and outdoor activities involving physical activities affording a workout. Accentuating the feeling of accomplishment by providing opportunities to “*feel the burn*” and simplified creative exercise routines modulated for older adults like “*wall push ups*”. I have demonstrated in this thesis that providing flexibility of design of gamified PA technology affords intangible rewards like bragging rights, building up one’s reputation, accomplishments, and confidence meter in doing progressively difficult tasks, and creating interactions to foster increase in confidence.

Relevance of Technology: This showed that while older adults are challenged by using technology, incorporation of gamification elements was well received. However, the understanding of the terminologies used in gamification and game design could hinder the gamifications experience. This is because older adults may have preconceived notions about games and gaming (Gerling, Schulte, et al., 2011; Heinz, 2013; Mouton & Cloes, 2013; van Stralen et al., 2010). Therefore, to facilitate an easier understanding of the gamification

application by older adults, methods to explain and educate them about terminologies must be addressed through the process of onboarding by interjecting game and gamification terminologies into the gamified technology. This will help older adults to feel in control of the system and instil a sense of agency among them in the form of a personal connection.

Tailoring PA Technology to Address Individual Needs: The importance of differentiating individual physical limitations and age-related impairments causes more difficult scenarios to deploy PA technology (Denise Astrid Peels et al., 2013; van Stralen et al., 2010). This thesis demonstrated that introducing gamification elements to test the acceptance of games contributed to showing that simple, changeable, and easily doable exercise routines interjected with a few difficult routines provided older adults with the confidence in doing such PA. This allowed older adults to feel that they were improving their ability to do PA measured by progression tracking and extrinsic rewards like stars and points. Furthermore, giving older adults the choice of multiple paths in a gamified app based on their diverse spectrum of PA challenges using technology helps to simplify a complex scenario due their physical and health related limitations. This fosters agency within a gamified platform thereby affording mastery.

10.5 The Path to Adaptive Engagement using Gamification

Adaptive gamified learning indicated modulating learning environment based on student behaviour and performance. (Barata, 2015). Adaptive engagement refers to creating flexible and interchangeable systems for PA that are tailored to the needs, physical limitations, and motivation of older adults. This adaptive nature of the gamification technology is needed to address their capabilities and ability based on physical and age-related limitations. Progression in this research and findings from this thesis, allow us to infer that engagement and enjoyment can be fostered through the deployment of personalized and customized gamification technology.

I defined the term *adaptive engagement* which means: *tailoring of older adults' engagement through customization and personalization of motivational affordances for PA* (Kappen et al., 2018).

Based on the findings from this dissertation (Chapter 6, Chapter 8, and Chapter 9), the experiential aspect of adaptive engagement in PA for older adults can be achieved in the following three steps:

1. Facilitating intrinsic motivation of older adults for PA,
2. Fostering PA through extrinsic motivation,
3. Encouragement through feedback cycles.

This thesis demonstrates the use of gamification elements as motivational affordances to improve the experience of PA for older adults by enabling goal selection, selection of challenges, focussed iterative and incremental task completion steps, and progression along the path of the selected quest. This differentiation through PA technology contributes towards fostering intrinsic and extrinsic motivation in older adults. Providing users with the possibility of feeling in control and choice of selection - also referred to as agency in game design, is a powerful element in contributing to autonomy when doing PA. Flexibility of the gamification application to facilitate agency and increased options at various levels of the application can help older adults feel more engaged in the application. Being able to customize these choices would give greater feeling of control leading to more enjoyment in the older adult demographic.

The ability to feel competent in doing PA at specified tasks provided by the gamification application affording competence can be facilitated by motivational affordances like incremental intensities of exercises, ability to feel validated for efforts and capability to perform PA activities correctly.

Based on the findings from the five phases illustrated above, the following items are crucial for facilitating engagement and enjoyment in PA for adults through gamification.

Intrinsic Motivation Elements	Guidelines
Attainable goals	Understanding the ability that is specific on an individual level should be the focus of PA goals (quests).
Challenges mirroring ability	Increasing challenges progressively to reflect the individual's ability so that it inspires confidence and provides a sense of accomplishment.

Intrinsic Motivation Elements	Guidelines
Increased agency	Challenges and levels should provide older adults with the feeling of a sense of being in control of their bodies based on their own physical limitations.
Choice of types of exercises	Combining activities to provide exercise and PA that improve endurance, flexibility, strength training within an indoor and outdoor environment.
Choice of intensity increases or decreases	Gamification of PA activities should have provisions of trying out new challenges or change the intensity level so that the activity feels like a challenge or have the potential of downgrading the challenge.
Inspiring curiosity	Gamification elements should provide the opportunity to provide a mystery PA module for older adults to try out for a new reward.
Interjecting unpredictability	The opportunity to do random PA activities to increase levels and rewards fosters the element of engaged participation.
Facilitating spontaneity and instantaneous gratification	Include elements that allow for spontaneous PA and instantaneous gratification in the form of feeling the burn, completion, achievement as internalised rewards.
Freedom of usage and habit formation	Allowing the possibility of activities to be done anywhere and anytime with simplicity and memorability to help with habit formation.
Facilitating competency	Providing challenges that help promote health benefits and increased mental satisfaction.
Social facilitation	Providing the possibility for older adults to share and post achievements, challenges with specific routines.

Table 56: Adaptive Engagement Guidelines 1

Extrinsic Motivation Elements	Guidelines
Attainable rewards	Challenges should provide the opportunity of instantaneous rewards while scaffolding to inspire active participation. It gives older adults the feeling of satisfaction that certain tasks and milestones are achievable based on their ability, rewarded and measurable.
Validation of efforts	While receiving points and stars seemed frivolous, its attainment after doing PA activity provided a sense of validation of one's efforts.
Progression reflecting ability	Progression should show the competence of older adults in being able to do a specific level to afford a sense of accomplishment.
Progression reflecting efforts	Combining activities to offer exercise activities that provide endurance, flexibility, and strength training within an indoor and outdoor environment.
Highlighting achievements	Providing badges and points that help to showcase their achievements and completion of difficult challenges.

Extrinsic Motivation Elements	Guidelines
Intangible rewards	Rewarding ability to perform the tasks and complete the tasks and providing the opportunity for bragging rights, recognition, as well as achievement levels will contribute to engagement and enjoyment of the PA activity.
Tangible rewards	Facilitate usage of experience points earned to be redeemed for ancillary contexts such as diet plans, fitness plans, fitness gear, books and competitions.

Table 57: Adaptive Engagement Guidelines 2

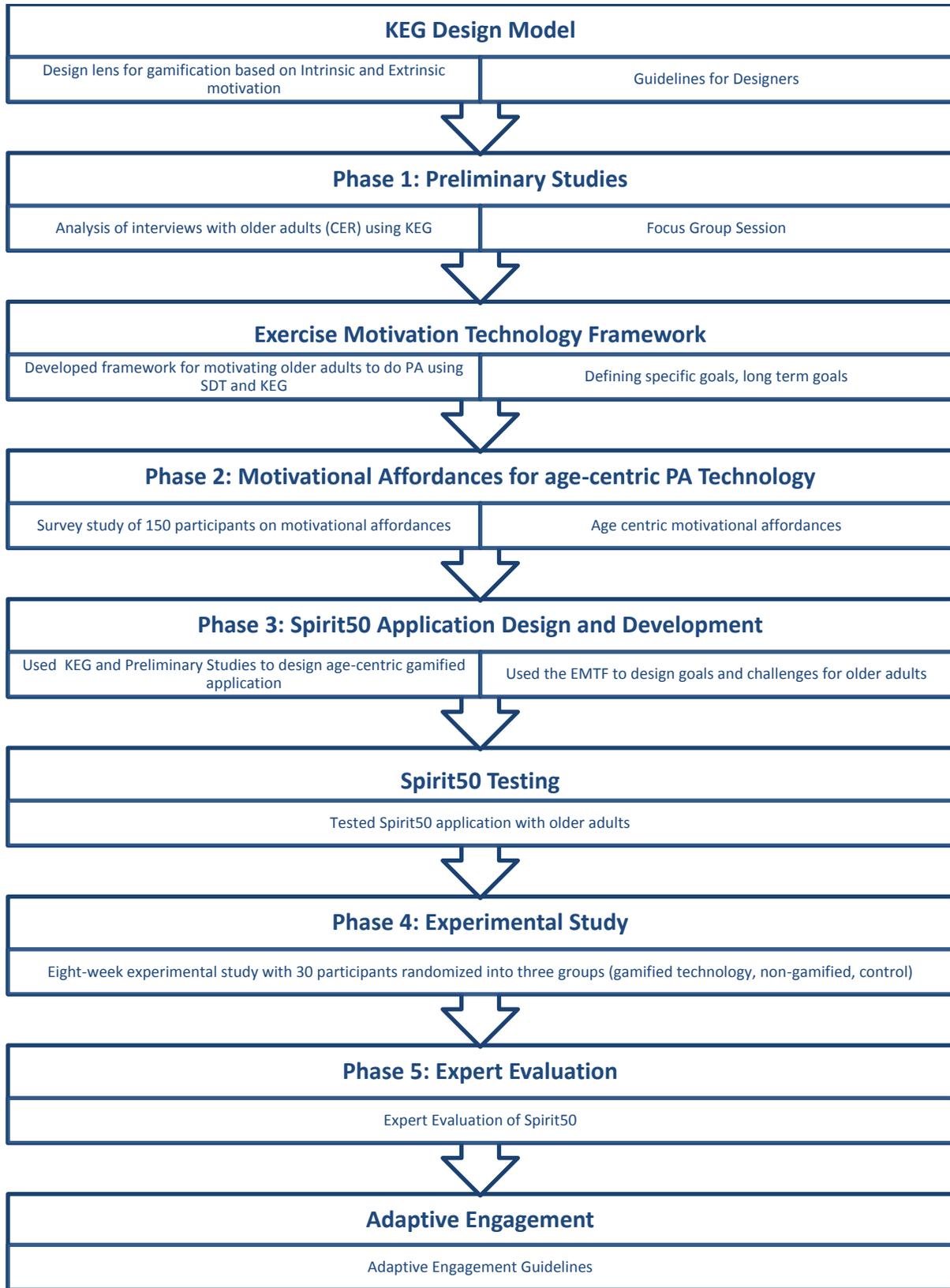


Figure 45: Stages in Research that led to the Adaptive Engagement Guidelines

Feedback Cycle Elements	Guidelines
Correctness of form	Real-time feedback on posture correction, gait and correctness of stance when doing the exercise routines is a difficult technology challenge but was desired by many older adults for increased participation.
Performance characteristics	The possibility of providing feedback on reps and steps, speed of completion, and tracking metrics such as calorie burn, heart rate, weight loss provides increased engagement
Encouragement through praise	Real-time feedback in the form of praise and checkmarks for task completion through the gamification app will help to reassure older adults
Visual representation of progression	Progression representation of daily, weekly and monthly indicating competence in all or specific activities in a graph format is more easily understandable by older adults
Onboarding and education	Older adults should have the opportunity to overcome challenges with understanding game, gaming and gamification terminology through training and education modules of the gamification app

Table 58: Adaptive Engagement Guidelines 3

10.6 Validity

The survey study (Chapter 6 – Phase 2), is valid because items within the survey instrument reported Cronbach’s $\alpha > 0.8$ (Section 13.4.3) indicating reliability between the scale items being measured. While a prior systematic review of gaming applications to improve physical activity indicated the use of metaphors and avatars to visualize activity, rewards, and competition were the most commonly used game elements to gamify PA applications (Tabak et al., 2015) which did not identify age-differentiated gamification elements. This survey study supports the validity of the research questions by identifying age-differentiated gamification elements for PA.

The experimental study (Chapter 8 – Phase 4) used validated scales for the outcome measures for enjoyment and engagement (IMI), motivation (PNSE), and performance (RPE). This allowed for comparison of the dependent variables across the three groups. Internal validity of the research design (in Phase 4) is also established because the method used in the experimental study was also used by other researchers to compare traditional web-based PA interventions and a control group (Irvine et al., 2013), enhanced internet based PA interventions and control groups (Carr et

al., 2013), and a four-week web-based intervention program to promote PA (Barwais et al., 2013).

The evidential chain (Figure 43) resulting from the qualitative analysis also showed similarities with the themes that emerged in a systematic review on older adults perceptions to participate in PA (Franco et al., 2015). This prior research indicated six major themes for participation in PA: social influences (valuing interaction with peers, social awkwardness, encouragement from others, dependence on professional instruction); physical limitations (pain or discomfort, concerns about falling, comorbidities); competing priorities; access difficulties (environmental barriers, affordability); personal benefits of physical activity (strength, balance and flexibility, self-confidence, independence, improved health and mental well-being); and motivation and beliefs (apathy, irrelevance and inefficacy, maintaining habits). The qualitative analysis from the experimental study (Chapter 8 – Phase 4) indicated emergence of 20 distinct themes for *motivation* for PA (Section 8.6), showing similar categories for: aging well, fear of being unhealthy, and mental wellbeing with the category of personal benefits of physical activity from the prior systematic review. Themes for *setting up goals* for PA showed similarities with the themes from the systematic research for personal benefits of PA: improved appearance, committing time for PA activities (habit formation) and healthy outlook. Themes for *feeling of accomplishment* showed similarities with the theme of personal benefits of PA from the prior research for improved self-confidence and mental satisfaction. Themes from *fears and barriers for PA* showed similarities with physical limitations and access difficulties: health conditions, resources issues, performance and social issues. However, the themes that emerged in this dissertation extend the themes from this systematic review (Franco et al., 2015) on a more granular level by differentiating older adults *motivation for PA* into 20 themes as shown in (Section 8.6, Table 37); seven themes for *setting up goals* (Section 8.6, Table 38), 16 themes for *feeling of accomplishment* (Section 8.6, Table 39); seven themes for *fears and barriers* (Section 8.6, Table 40); 13 themes for *rewards and PA* (Section 8.6, Table 41); and seven themes for *tracking of PA* (Section 8.6, Table 42).

A 12-week Internet intervention to help sedentary older adults over 55 years of age indicated a positive impact of PA on sedentary older adult participants (Irvine et al., 2013). While the gamification elements used in Spirit50 were designed for *active lifestyles* (Section 4.2), these technology interventions are applicable for overcoming sedentariness among older adults. These comparisons show that it is important to initiate PA using technology interventions at age as early as 50 years of age to support habit formation when they reach 65 years of age. This allows for the generalizability of the findings of this dissertation leading to external validity.

10.7 Summary

This chapter illustrated the impact of designing adaptive engagement artifacts for PA facilitation using gamification as a technology strategy to facilitate PA. The summary of findings from the five phases contributed to understanding PA motivation of older adults on a granular level. The chapter also discussed the implications of designing PA technology for older adults.

Furthermore, based on empirical findings, the chapter also provided detailed guidelines on the pathways to create gamified PA technology for older adults. The findings also indicate congruence with the EMTF framework discussed in prior sections (5.6) indicating that differentiating PA motivation of older adults based on goals, barriers to PA and current health conditions are related to exercise intensities and types of exercise provided within the gamification artifact.

Persuasive technology used to investigate the motivation of older adults (55 to 77 years of age) to exercise indicated that technology for PA should have minimal attention and cognitive effort from older adults (Rodríguez, Roa, Morán, & Nava-Muñoz, 2013). Spirit50 was designed for helping adults (50+) to be more engaged in PA through the usage of gamification elements to foster behaviour change by providing continuous feedback of their daily progress, rewarding efforts and accomplishments, providing challenging tasks and rewarding task completion over an eight-week period. While study on older adults intrinsic and extrinsic motivation (50 – 79 years of age) indicated health and fitness, social/emotional benefits, weight management, stress management, and appearance to be motivators for PA, enjoyment was the key differentiator for influencing PA (M. Dacey et al., 2008). This dissertation extends this study by differentiating

moderators for PA into the following categories: motivations for PA, setting up goals, feeling of accomplishments, fears and barriers, rewards and PA, and tracking and PA. These categories are categorised further into detailed dimensions based on axial codes emerging from qualitative analysis (Section 8.6). Quantitative analysis from the experimental study indicated significance in the perceived interest and enjoyment dimensions of the IMI (Section 8.6.2) for the gamified group of participants.

Tailored PA interventions for older adults (over 50 years of age) resulted in timed and opportunity based education of older adults to promote the benefits of PA (van Stralen et al., 2008). In this dissertation, qualitative analysis of the experimental study also indicated a progressive increase in difficulties and challenges led to increased feeling of confidence, improved feeling of satisfaction and improved health conditions. A study investigating long-term efficacy of computer tailored PA interventions for older adults, participants recruited were over 50 years of age, resulted in behavioural changes in physical activity behaviour of older adults (Denise Astrid Peels et al., 2013; van Stralen et al., 2011). Gamified intervention using PA technology used in this dissertation also indicated positive behaviour change of older adults towards PA due to reinforcement of efforts by motivational affordances, and feeling validated for their achievements through a rewards mechanism.

Chapter 11

11 Conclusion

Gamified PA technology can serve as a behaviour change mechanism to facilitate daily and routine activities in the range of light, medium, and strenuous activities to achieve their health and fitness goals. This concept of interjecting motivational affordances to foster intrinsic and extrinsic motivations of older adults for PA must be supplemented with constant feedback leading to encouragement and confidence building scenarios. To achieve the experiential state of enjoyment and engagement of older adults in PA, this dissertation demonstrates the application of the EMTF for PA motivation based on granular differentiation of their goals, barriers to PA and current health conditions. Qualitative analysis using thematic analysis showed that differentiating PA motivation of older adults based on triggers for PA, setting up goals, feeling of accomplishment, fears and barriers to PA, and rewards was facilitated by the intensity of the routine (high, medium and low) and the type of exercise or PA (endurance, flexibility and strengthening) and barriers.

11.1 Contributions

This dissertation makes significant contributions in the three areas of older adults and motivational affordances for PA, development of an exercise motivation technology framework (EMTF), and the Kaleidoscope of Effective Gamification (KEG).

11.1.1 Older Adults and Motivational Affordances for PA

1. This dissertation developed age-differentiated guidelines for incorporating motivational affordances into technologies to facilitate PA.
 - a. Identified age-group specific motivational affordances for age groups: 18-29 years old, 30-49 years old, 50-64 years old, and 65+ years old based on differences in motives for becoming physically active.
 - b. Distinguished preferences for technology facilitated PA to classify motivational elements into gamified motivational affordances and feedback elements.

- c. Age-specific design guidelines provided the understanding of how interactive technologies can meet the needs of adults in different age groups to enable us tailor meaningful fitness and PA technologies.
2. This dissertation developed the adaptive engagement guidelines for older adults and incorporating motivational affordances in PA technology.
 - a. Granular differentiation of older adults' motivations for technology facilitated PA for customization and personalization of health, wellness and fitness artifacts as *behaviour change agents* from the point of tailoring their engagement for motivated PA leading to *adaptive* engagement.
 - b. Defined a better understanding of the intrinsic and extrinsic motivations, barriers, and goals that encourage older adults' engagement with technology in physical activities is critical for tailored technology systems.
 - c. Investigated a gamification strategy that uses these intrinsic and extrinsic motivations to allow for adaptive engagement.
 - d. Identified adaptive engagement guidelines based on empirical evidence for intrinsic motivation for older adults to be fostered by the following dimensions: *Attainable goals, challenges mirroring ability, increased agency, choice of types of exercises, choice of intensity increases or decreases, inspiring curiosity, interjecting unpredictability, facilitating spontaneity and instantaneous gratification, freedom of usage and habit formation, facilitating competency, and social facilitation*
 - e. Identified adaptive engagement guidelines for extrinsic motivation to be fostered by the following dimensions: *attainable rewards, validation of efforts, progression reflecting ability, progression reflecting efforts, highlighting achievements, intangible rewards, and tangible rewards.*
 - f. Identified adaptive engagement guidelines for feedback cycle to be fostered by the following dimensions: *correctness of form, performance characteristics, encouragement through praise, visual representation of progression, onboarding and education*
3. This dissertation provides better understanding of health and wellness goals of older adults through gamification.

- a. Provided empirical evidence that gamification can be used as a behaviour change agent to motivate older adults to engage in PA.
- b. Gamified PA technology, as customizable interventions could provide simplified interactions for older adults to facilitate habit formation and increased exercise motivation to maintain PA over longer durations.

11.1.2 Exercise Motivation Technology Framework (EMTF)

- 4. Results from the mixed-method studies helped with the development of the revised Exercise Motivation Technology Framework
 - a. This dissertation developed the *Exercise Motivation Technology Framework* (Figure 44), PA technology development tool which combines desirability (motivation), customization (ability differentiation), and motivational affordances on how to improve older adult's exercise motivation using gamified technology systems.
 - b. Provided a structured method to incorporating PA motivations based on recognizing the need to design towards older adults age-related abilities.

11.1.3 Kaleidoscope of Effective Gamification (KEG)

- 5. Developed the Kaleidoscope of Effective Gamification, a design tool that provided a step by step iterative pathway to help designers in developing gamification apps using the following steps: identify motivation or desirability element within the target demographic; design the experiential play; incorporate interaction elements; incorporate fun elements to afford hedonia and eudaimonia (Huta & Waterman, 2014; R. M. Ryan et al., 2006). This tool was used as a design and analysis tool in this research investigation.

Physical activity is important at all life stages, and while health technologies and gamified fitness strategies have been widely adopted by the younger population, little technology is available to support older adults wishing to maintain physical activity routines. This work provides first insights into older adults' perceptions of fitness technologies, with the goal of helping researchers and designers to better understand design challenges when creating applications for this demographic. This is an important step in the development of meaningful health technology

applications for older adults. This would allow individuals to apply technology in the improvement and maintenance of fitness behaviours that promote physical and mental wellbeing. Based on my study, the guidelines of adaptive engagement could help designers and developers create new PA technology artifacts (applications) for older adults. Since studies have provided insights into intrinsic and extrinsic motivators for older adults to engage in PA, the next step would be to integrate these motivations in the design of rules and goals for an accessible mobile artifacts or wearable technology devices.

Detailed understanding of relevant motivational and personality characteristics will enable developers to create interactive and gamified fitness applications tailored to address selective customization of interface elements, challenges, rewards, and achievements. My original contribution to the advancement of knowledge through this research is the development of the KEG theoretical model and its use as an analytical lens, the EMTF and the adaptive engagement guidelines. Additionally, the analysis method of combining the KEG (a gamification model) and SDT (a psychological theory) model towards fitness gamification for older adults is a new approach to analyzing internalized motivations of older adults to engage in PA.

The usage of KEG and SDT to design the EMTF for designing gamified PA technology for older adults is supported by empirical studies provided in the five phases of this thesis. The evidential chain from qualitative analysis and significant differences between gamified, non-gamified and control groups supported the hypothesis that gamified technology does increase enjoyment and engagement of older adults for PA. This thesis contributes to advance knowledge in the field of human-computer interaction and provides guidelines for gamification designers and developers working with technology for older adults.

11.2 Limitations and Future Work

More work is necessary to survey attitudes towards technology-supported physical activity among sedentary older adults. Such research might reveal that a number of diverse technology solutions are necessary to meet the needs of the older population in full. Additionally, while the preliminary analyses of the rich qualitative data that was gathered provide a helpful starting point

for designers, they are limited with regard to the classification of personality types. In this context, an interesting continuation of this current study would be exploring the impact of personality types on exercise routines for older adults. Additionally, the perception of older adults towards gaming and gamification can be different from perception of others. Therefore, more research is needed to understand their outlook towards gaming and gamification terminology.

Aging also contributes to changes in personality affecting PA motivation which has been investigated from the perspective of modifiable factors like perceived chance of success, perceived importance of goals, inclination to remain sedentary and perceived costs (E. M. Phillips et al., 2004). Attitude and behaviour change towards a specific task are also moderated by personality (Goldberg, 1983; Plonczynski, 2000). While predictors of technology adoption has been investigated among older adults (Heinz, 2013), the specificity of the role of personality in the context of PA motivation and PA technology is also in need of investigation. Additional research on the role of personality traits of older adults and the exploration of changes in these traits with age will also be needed to tailor behaviour change technology for PA motivation.

In the context of gamification as well as quantified health applications, threshold data is rarely adjusted to older users (Schutzer & Graves, 2004a). For example, general fitness goals, such as taking 10,000 steps a day, may not be suitable (Schutzer & Graves, 2004a) for older adults with age-related mobility impairments. Therefore, applications will need to adapt such features in the interest of addressing concerns related to both motivation and safety for older users.

Concerns about placebo effects in games (Denisova & Cairns, 2015) are also critical to determine what is mediating the observed behaviour. In the experimental study (Chapter 8-Phase 4), participants in the gamified and non-gamified group may expect to have more engagement because of the presence of new features in the technology artifact (i.e., a novelty effect). There were also the occasions when participants from the gamified and non-gamified forgot to perform their weekly tasks because of their daily-life activities. There was also the possibility of risk of a participant not willing to do the specified daily PA on specific days' due mood swings (P11) and general lethargy (P08) in specific weeks. This posed the limitation of

participants not adhering to the exercise plan of a weekly basis for the eight-week intervention period. Three participants dropped out of the control group and new recruitment had to be done of the study protocol prior to the 8-week period.

In a similar vein, technology that older adults use to exercise should not replace the personal relationship that they have with their trainer and peers. A computer based virtual trainer would likely not have the same motivational effect on older adults than a real-life person would. Small functional feedback might be acceptable, but for the main part, the technology should enable communication with real people that allows older adults to keep as connected and social as they would be when exercising in a gym together. Physical limitations and barriers caused by increasing age is diverse for each individual. While motivational affordances do contribute to higher engagement and better experience in exercise and daily PA, tailoring any artifact to meet the individual needs and preferences of the older adult demographic is another daunting task. Additionally, usability issues, challenges with using technology, reluctance to use technology (big-brother outlook) and reduced finances represent a few more limitations within this demographic.

11.3 Closing Remarks

This thesis demonstrated that motivational affordances in the form of gamification technology can be used to foster intrinsic and extrinsic motivations among older adults for PA. The findings of this dissertation contribute to the understanding PA motivation of older adults on a granular level from a technology facilitation standpoint by differentiating older adults *motivation for PA* into 20 themes as shown in (Section 8.6, Table 37); seven themes for *setting up goals* (Section 8.6, Table 38), 16 themes for *feeling of accomplishment* (Section 8.6, Table 39); seven themes for *fears and barriers* (Section 8.6, Table 40); 13 themes for *rewards and PA* (Section 8.6, Table 41); and seven themes for *tracking of PA* (Section 8.6, Table 42). Motivational affordances leveraging repetitive actions leads to the possibility of habit formation, which in turn assists in modifying one's attitude and behaviour towards health-related everyday tasks such as drinking eight glasses of water, or maintaining a correct posture and maintaining portion control of food intake. All these outcomes of motivational affordances become purposeful when it fosters hedonia (pleasure, enjoyment and satisfaction) and eudaimonia (personal growth, striving for

excellence, better outlook in life and self-regulation) (Huta & Waterman, 2014; R. M. Ryan et al., 2006). The research from this dissertation indicated that motivation for PA can be facilitated through gamification technology. However, the guidelines of *adaptive engagement* help to tailor PA technology for older adults in a manner that the gamified technology is customized and personalised to the needs and wants of the demographic. In specific, this dissertation has provided a method for tailoring gamified PA technology using the EMTF to design for the current health conditions, age-related barriers and limitations, and ability of older adults while being cognisant of usability and interaction modalities.

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Appendix

13 Appendix

13.1 Phase 1: Informal Focus Group Questions

We created a new questionnaire for a focus group discussion session with older adults. This set of questions focused on intrinsic and extrinsic motivational triggers to engage, maintain and sustain motivation in a fitness activity.

These questions were grouped under amotivation; motivation (competence, autonomy, relatedness); social validation (social interaction, sharing, participation); accountability; and staying on track.

Amotivation (Barriers)/ Motivations	What are a few mental thoughts that prevent you from participating in a fitness program that you were interested in trying? What are they? What helps you overcome these challenges?
	What are the physical things that prevent you from participating in fitness programs? What are they? What helps you overcome these challenges?
	Did you ever stop a physical activity that you used to do? And Why?
	When do you feel capable of doing a fitness program?
	What makes you feel effective in doing a fitness programs?
	When do you feel competent in doing a fitness routine?
	Would external rewards help to overcome your mental and physical barriers?
Goals and Accomplishments	Have you ever set an activity goal?
	What are the kinds of goals that you create to help you stay motivated to fitness programs?
	What motivates you to set up goals?
	When do you feel that you have accomplished a goal?
	Are you interested in different fitness programs options and choices available to you?
	What makes a fitness program interesting for you?
	How much freedom do you want when doing your fitness programs?
	Tell us about a fitness accomplishment? And what motivates you about such an accomplishment?
	Do you feel you should be rewarded for your accomplishments? How?

Physical Tracking	Do you have a preference of specific types of tracking? Do you track anything yourself?
	What would you like to see indicated by an activity-tracking device? Is there anything from such a device that you feel would help you stay motivated? Why? (Physical activity, step counter, movement tracker)
Accountability	When you have a personal goal do you like to be accountable to yourself or others in hitting the goal?
	How do you stay accountable to your own goals?
	Does accountability help you stay motivated?
	Do you feel that you need to be rewarded to remain accountable to your goals?
	When has accountability to someone else worked well to help you stick to a goal?
Staying on Track	Do you prefer participating in a fitness routine with or without equipment?
	Do you like to use fitness equipment and if you do how do you use it?
	Does getting feedback on your progress motivate you to keep indulging in fitness routine?
Social Validation (Social, Sharing, interaction)	Do you feel motivated to fitness programs when you are part of a group? Does a group motivate you to fitness programs?
	What part of being in a group motivates you most to fitness programs? (challenge, competition, cooperation)
	Do you like help from other people to help to keep you on track to a goal or do you like to do it on your own?
	How do you feel about praise? Is praise important to you?
	What information about your fitness programs would you be comfortable sharing with a group?
	How important are social relationships as part of your fitness programs?
	Do you feel positive or negative about closeness to other people when exercising?
	Are emotions important to you when participating in a fitness routine? Emotions of other people or coaches?

Table 59: Appendix 12-1 - Informal Focus Group Questions

13.2 Phase 1: Vague Goal to Specific Goals (One-to-Many) Relationship Matrix

SDT/KEG MODEL	Vague Goals	intensity (low, medium, high)	Specific Goals
	<i>What motivates you to exercise?</i>		<i>What do you want to do?</i>
Competence	Have a more active life		Exercise for 30 mins most days of the week
Competence			Get in the habit of taking the stairs, walking as transportation and sitting less
Competence	Stay Flexible		More easily touch my toes when seated in the next 3 months
Competence			Pull a sweater over my head without shoulder pain
Competence			Putting on socks from a seated position
Competence			Have visibly improved posture
Competence			Reduce pain and stiffness in my upper body
Competence			Reduce pain and stiffness in my lower body
Competence	Improve energy levels		Have more steady energy throughout my day
Competence			Be able to do more activities in my day without feeling tired
Competence	Sense of accomplishment		
Competence	Mobility		
Competence	Feel Good		Feel less stressed and more relaxed on a day to day basis
Competence			Reduce pain and stiffness in my upper body
Competence			Reduce pain and stiffness in my lower body
Competence			Feel more positive when I wake up
Autonomy	Boost Independence		Easily climb the stairs in my home
Autonomy			Get up and down off the floor independently
Autonomy			Do my own gardening
Autonomy			Do my own home maintenance including changing light bulbs, carrying laundry bins)
Autonomy			Maintaining balance during challenging movements (e.g. walking on uneven ground)
Autonomy			Easily step on/off a bus and get in and out of my car

Autonomy			Moving quickly around the house (e.g. getting to the door or phone quickly)
Autonomy	Increase Endurance		Recreational activities involving changes in position and posture (e.g. golf, curling, dancing)
Autonomy			Walk a distance of 1 mile (1.6 Km)
Autonomy	Look and feel stronger		Carry heavy (12-15) lb grocery bags from the car with ease
Autonomy			Have visibly improved posture
Autonomy			Introduce weight training to my life
Autonomy	Overcome sedentary lifestyle		Be active for at least an hour every day
Autonomy			Only sit for short durations throughout my day
Autonomy	Prevent Falls		Maintaining balance during challenging movements (e.g. walking on uneven ground)
Autonomy			Strengthen the muscles in my legs and ankles to make me more stable
Autonomy	Brian Health		Do the best exercises to prevent cognitive decline
Relatedness	Connecting with other people		
Relatedness	Sharing goals keeps me on track		
Relatedness	Inspire friends		
Extrinsic	Lose weight		Lose a half to a pound every week or two
Extrinsic	Burn Calories		Do the right amount of exercise to maintain my current weight
Extrinsic			Fit into smaller pants
Extrinsic	Look Younger		
Extrinsic	Tone Body		Have more muscle definition in my upper body
Extrinsic			Have more muscle definition in my lower body
Extrinsic	Train for a sports event		Walk a 5km race in the next 6 months
Extrinsic			Run a 5 km race in the next 6 months
Extrinsic			Play a game of tennis
Extrinsic			Golf 18 holes walking the course
Extrinsic	Prepare for a trip		Be able to lift a carryon bag into the overhead compartment on the airplane
Extrinsic			Improve walking endurance for sightseeing

13.3 Gamification Definitions

Gamification Definition	Context	Month	Year	Source	Type
Game ideas to other areas			2002	Nick Pelling	website
"taking game mechanics and applying to other web properties to increase engagement"	"gamification" of the web	June	2008	Brett Terrill (2008-06-16). http://www.bretterill.com/2008/06/my-coverage-of-lobby-of-social-gaming.html	Website
"taking action in a well-defined context with a clear rewards structure can be flat out meaningful for people"	marketing	November	2008	James Currier (2008-11-05) http://blog.oogalabs.com/2008/11/05/gamification-game-mechanics-is-the-new-marketing/	Website
"Driving deeper customer engagement through the Power of Play"	gamification of loyalty	July	2009	Barry Kirk and Tim Crank (2009-07) http://www.scribd.com/doc/17718638/Loyalty-Expo-2009-in-Review	
With "gamification," companies study and identify natural human tendencies and employ game-like mechanisms to give customers a sense that they're having fun while working towards a rewards-based goal	Industry	September	2010	JP Mangalindan (2010-09-03). "Play to win: The game-based economy". <i>Fortune</i> (magazine). Retrieved 2014-10-13 http://fortune.com/2010/09/03/play-to-win-the-game-based-economy/	Magazine
"The process of game-thinking and game mechanics to engage users and solve problems"	Industry	August	2011	Zichermann, Gabe; Cunningham, Christopher (August 2011). "Preface". <i>Gamification by Design: Implementing Game Mechanics in Web and Mobile Apps</i> (1st ed.). Sebastopol, California: O'Reilly Media. pp. ix, 208. ISBN 1449315399.	Book
"the use of game design elements in non-game contexts"		Sept	2011	Deterding, S., Dixon, D., Khaled, R., & Nacke, L. E. (2011). From Game Design Elements to Gamefulness : Defining " Gamification ." In <i>MindTrek'11, September 28-30, 2011, Tampere, Finland</i> . (pp. 9–15).	peer reviewed paper
"the addition of elements commonly associated with games (e.g. game mechanics) to an educational or training program in order to make the			2011	Landers, R. N., & Callan, R. C. (2011). Serious Games and Edutainment Applications. In M. Ma, A. Oikonomou, & L. C. Jain (Eds.), <i>Serious Games and</i>	

learning process more engaging"				<i>Edutainment Applications</i> (pp. 399–423). London: Springer London. doi:10.1007/978-1-4471-2161-9	
"a process of enhancing a service with affordances for gameful experiences in order to support user's overall value creation"	Service Industry-Marketing	Oct	2012	Huotari, K., & Hamari, J. (2012). Defining Gamification - A Service Marketing Perspective. In <i>Proc. of MindTrek 2012</i> .	peer reviewed paper
"Gamification is the use of game elements and game design techniques in non-game contexts"	Business	Oct	2012	Werbach, K. and Hunter D. (2012). <i>For The Win</i> . Philadelphia: Wharton Digital Press.	Book
"as incorporating game elements into a non-gaming software application to increase user experience and engagement"		Dec	2012	Domínguez, A., Saenz-de-Navarrete, J., de-Marcos, L., Fernández-Sanz, L., Pagés, C., & Martínez-Herráiz, J.-J. (2013). Gamifying learning experiences: Practical implications and outcomes. <i>Computers & Education</i> , 63, 380–392. doi:10.1016/j.compedu.2012.12.020	
"Gamification is the craft of deriving all the fun and addicting elements found in games and applying them to real-world or productive activities"	Industry	April	2013	Chou, Y., <i>Octalysis: Complete Gamification Framework</i> http://www.yukaichou.com/gamification-examples/octalysis-complete-gamification-framework/ (12.04.2013)	website
"Gamification is implementing design concepts from games, loyalty programs, and behavioural economics to drive user engagement"	Industry	June	2013	Zichermann, G. and Linder J.(2013). <i>The Gamification Revolution</i> . New Delhi: McGraw Hill Education (India) Private Limited.	Book
"simple gameplay to support productive interaction for expected types of learners and instructors"	education	June	2013	Rughiniş, R. (2013). Gamification for Productive Interaction Reading and Working with the Gamification Debate in Education. In <i>Proc. of 8th Iberian Conference on Information Systems and Technologies (CISTI)</i> (pp. 1–5).	peer-reviewed
"gamification should influence human behaviour through engaging experiences, using game design principles in decision-making applications"		October	2013	Kappen, D. L., & Nacke, L. E. (2013). The Kaleidoscope of Effective Gamification : Deconstructing Gamification in Business	peer-reviewed

and services not related to gaming"				Applications. In <i>Gamification 2013</i> (pp. 119–122).	
"the process of making activities more game-like"		January	2014	Werbach, K. (2014). (Re) Defining Gamification. <i>Persuasive 2014, Lecture Notes in Computer Science 8462 (2014), 2014</i> (January).	
"the use of game mechanics and experience design to digitally engage and motivate people to achieve their goals"		April	2014	Brian Burke (2014-04-04) http://blogs.gartner.com/brian_burke/2014/04/04/gartner-redefines-gamification/	website
"employer-imposed game in a work environment where the goals of the game are designed to reinforce the goals and purpose of the employer"	Industry	September	2014	Mollick, E., & Rothbard, N. (2014). Mandatory Fun : Gamification and the Impact of Games at Work. <i>The Wharton School Research Paper Series</i> , (September), 1–51. Retrieved from http://dx.doi.org/10.2139/ssrn.2277103	
"the intentional use of game elements for a gameful experience of non-game tasks and contexts"		October	2014	Seaborn, K., & Fels, D. I. (2014). Gamification in Theory and Action: A Survey. <i>International Journal of Human-Computer Studies</i> , 74, 14–31. doi:10.1016/j.ijhcs.2014.09.006	

13.4 Phase 2: Survey Study for Gamification

13.4.1 Survey Questionnaire for Gamified PA

This questionnaire was developed using the constructs of game design elements (Deterding, Dixon, et al., 2011)(Deterding, Sicart, et al., 2011), KEG(Kappen & Nacke, 2013), need satisfaction (Deci et al., 1994a)(R. M. Ryan & Deci, 2000a) and some elements of the Physical Activity Scale for the Elderly (PASE) (Bolszak et al., 2014) and Community Healthy Activities Model Program for Seniors (CHAMPS) (Stewart et al., 2007).

Participation in daily physical activities is critical to overcome a sedentary lifestyle. If you are participating in daily physical activities and exercises to maintain and improve your health and wellbeing, using devices and apps to help you monitor your physical activities and exercise routines, please participate in this survey to help advance our research in technology facilitated physical activities.

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Description:

This Online Survey Study is planned to be a survey on the preferences of technology applications used for fitness and physical activity (PA) by individuals when performing their daily physical activity routines. We are interested in finding similarities and differences between adults in motivation to participate in PA through the following:

- use of technology artifacts (devices and/or apps) for physical activity or exercises
- use gamified (use of game elements) technology applications for PA
- influence of behaviour change affordances as motivations to participate in physical activity or exercises.

Inclusion Criteria: If you are over 18 years of age and meet ANY "**ONE**" of these descriptions, your participation is requested at this time.

- Participate in **LIGHT OR MODERATE OR STRENUOUS** physical activity:
- Light physical activity: slow walking, making the bed, eating, preparing food, and washing dishes.
- Moderate Physical Activity: sweeping the floor, walking briskly, slow dancing, vacuuming, washing windows, shooting a basketball.
- Strenuous Physical Activity: running (5 mph >), swimming, shoveling, soccer, jumping rope, carrying heavy loads (i.e. bricks)
- More examples about these types of activities can be seen at - [IGROW](#) and at the [Harvard School of Public Health](#)
- Use a digital health tracking or self monitoring device like Fitbit or use apps like GoogleFit, SamsungHealth, pedometer or similar health tracking apps for monitoring your health and physical activities.
- Use any of these devices: cellphone, smartphone, tablet, laptop, or desktop computers for social media applications like Facebook, Instagram, and Pinterest to mention a few OR for playing digital games.
- Use any of these devices: cellphone, smartphone, tablet, laptop, or desktop computers for playing digital games.

Expected benefits

It is expected that this project will not benefit you directly. However, it may benefit you indirectly as the research will hopefully lead to the production of more physical activity monitoring applications and to a better understanding of what motivates people to participate in Physical Activities.

*To recognize your contribution, should you choose to participate, the research team is offering you the **chance** to win one of three Amazon.ca gift cards (to the value of \$30CDN each, redeemable only at Amazon.ca). (Amazon.ca has no involvement with the study and neither they or anyone else outside the research team will be given access to your data.) If you choose to enter the draw for the voucher you will need to provide some basic contact information. However, your identity will not in any way be connected to your responses to the survey.*

Risks There are no specific risks associated with the questions used in this anonymous survey study. Some questions are directed towards understanding your current health conditions and activity lifestyle. Specifically, there are questions related to employment, education and household income; if you are not comfortable in giving specifics, you may choose to decline to answer by selecting the option "would rather not say". These questions are optional and should you be concerned about answering these questions, you could skip answering these questions. A few additional risks are explained below.

Psychological/Social Risks: You will be asked information about your motivations and fitness habits and related preferences. You may disclose information that may be embarrassing which can possibly be a psychological or social risk. You can choose to withdraw at any time during the online survey, and your incomplete data will not be used. Additionally, you can choose to select the option "would rather not say" in a question pertinent to household income to avoid answering a question. Any of these actions can be taken without reason. Withdrawal from the study will not lead to any penalization.

You may decline to answer any questions that you do not wish to answer and can withdraw your participation at any time by not submitting responses.

Coercion: Some participants who may be family and friends may feel coerced into participating in this study. Since participation is voluntary there is no coercion. Your participation and it is completely voluntary and you can choose to stop the survey study and withdraw your participation at any point during the survey.

Withdrawal procedure for online survey:

Your participation in this online survey study is completely voluntary and you may interrupt or end this user survey study by closing your browser window, at any time without giving any reason. Withdrawal from the study will not lead to any penalization. Since your answers are anonymous, it is difficult to track your survey session with the answers provided by you. If you withdraw at any time without completing the survey, your withdrawal will result in an incomplete survey session. This incomplete survey session will be deleted from the dataset.

Statement of Consent to Participate

By clicking on the 'Next' button below, you are indicating that you:

- Have read and understood the above information regarding this project. Have had any questions answered to your satisfaction.
- Are over 18 years of age
- Understand that if you have any additional questions you can contact the research team.
- Understand that you are free to withdraw at any time, without comment or penalty.

Agree to participate in the survey

Please click on 'NEXT' if you agree to the above statements and are ready to begin the survey.

There are 62 questions in this survey

Motivation to participate in physical activities-1

This question represents the various participation motives as outlined in the Exercise Motivations Inventory (Markland et al.1997). Please select your answers to provide information about the reasons why you choose to participate in physical activity sessions on your own or at a gym **Please select your choices from the scale to inform us about your reasons to participate in physical activities on a daily or weekly basis; individually or at a training/gym facility.**

Please take a few moments to select your specific choice so that your answers would help us to define our research direction.

Please choose the appropriate response for each item:

	1 (not all true for me)	2	3	4 (somewhat)	5	6	7 (very true for me)
To stay slim	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To avoid ill-health	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because it makes me feel good	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To help me look younger	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To show my worth to others	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To give me space to think	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To have a healthy body	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To build up my strength	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because I enjoy the feeling of exerting myself	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To spend time with friends	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Motivation to participate in physical activities-2

Please select your choices from the scale to inform us about your reasons to participate in physical activities on a daily or weekly basis; individually or at a training/gym facility.

Please take a few moments to select your specific choice so that your answers would help us to define our research direction.

Please choose the appropriate response for each item:

	1 (not all true for me)	2	3	4 (somewhat)	5	6	7 (very true for me)
Because my doctor advised me to exercise	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because I like trying to win in physical activities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To stay/ become more agile	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To give me goals to work towards	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To lose weight	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To prevent health problems	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because I find exercise invigorating	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To have a good body	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To compare my abilities with other peoples	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	1 (not all true for me)		2	3	4 (somewhat)	5	6	7 (very true for me)
Because it helps to reduce tension	<input type="radio"/>		<input type="radio"/>					

Motivation to participate in physical activities-3

Please select your choices from the scale to inform us about your reasons to participate in physical activities on a daily or weekly basis; individually or at a training/gym facility.

Please take a few moments to select your specific choice so that your answers would help us to define our research direction.

Please choose the appropriate response for each item:

	1 (not all true for me)		2	3	4 (somewhat)	5	6	7 (very true for me)
Because I want to maintain good health	<input type="radio"/>		<input type="radio"/>					
To increase my endurance	<input type="radio"/>		<input type="radio"/>					
Because I find exercising satisfying in and of itself	<input type="radio"/>		<input type="radio"/>					
To enjoy social aspects of exercising	<input type="radio"/>		<input type="radio"/>					
To help prevent an illness that runs in my family	<input type="radio"/>		<input type="radio"/>					
Because I enjoy competing	<input type="radio"/>		<input type="radio"/>					
To maintain flexibility	<input type="radio"/>		<input type="radio"/>					
To give me personal challenges to face	<input type="radio"/>		<input type="radio"/>					
To help control my weight	<input type="radio"/>		<input type="radio"/>					
To avoid heart disease	<input type="radio"/>		<input type="radio"/>					

Motivation to participate in physical activities-4

Please select your choices from the scale to inform us about your reasons to participate in physical activities on a daily or weekly basis; individually or at a training/gym facility.

Please take a few moments to select your specific choice so that your answers would help us to define our research direction.

Please choose the appropriate response for each item:

	1 (not all true for me)		2	3	4 (somewhat)	5	6	7 (very true for me)
To recharge my energy	<input type="radio"/>		<input type="radio"/>					
To improve my appearance	<input type="radio"/>		<input type="radio"/>					
To gain recognition for my accomplishments	<input type="radio"/>		<input type="radio"/>					
To help manage stress	<input type="radio"/>		<input type="radio"/>					
To feel more healthy	<input type="radio"/>		<input type="radio"/>					
To get stronger	<input type="radio"/>		<input type="radio"/>					
For enjoyment of the experience of exercising	<input type="radio"/>		<input type="radio"/>					
To have fun being active with other people	<input type="radio"/>		<input type="radio"/>					
To help recover from an illness/injury	<input type="radio"/>		<input type="radio"/>					
Because I enjoy physical competition	<input type="radio"/>		<input type="radio"/>					

Motivation to participate in physical activities-5

Please select your choices from the scale to inform us about your reasons to participate in physical activities on a daily or weekly basis; individually or at a training/gym facility.

Please take a few moments to select your specific choice so that your answers would help us to define our research direction.

Please choose the appropriate response for each item:

	1 (not all true for me)		2	3	4 (somewhat)	5	6	7 (very true for me)
To stay/become more flexible	<input type="radio"/>		<input type="radio"/>					

	1 (not all true for me)	2	3	4 (somewhat)	5	6	7 (very true for me)
To develop personal skills	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because exercise helps me to burn calories	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To look more attractive	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To accomplish things that others are incapable of	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To release tension	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To develop my muscles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because I feel at my best when exercising	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To make new friends	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because I find physical activities fun, especially when competition is involved	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
To measure myself against personal standards	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Physical Activity (PA) Questions-1

Physical Activity: A physical activity is defined as participating in walking, jogging, gardening, cycling, swimming, aerobics activity, dance or following an exercise activity routine using YouTube/online videos or using training videos and even doing household chores

[]Select from the following options *

Please choose **only one** of the following:

- Smoker
- Non-smoker
- Would rather not say
- None of the above

[]How many hours in a day do you sit in a day?

Please choose **only one** of the following:

- Less than 30 minutes
- Less than 45 minutes
- 1 - 2.5 hours
- 3 - 4.5 hours
- greater than 5 hours

[]How many hours do you sleep in a day?

Please choose **only one** of the following:

- Less than 1 hour
- 1 - 2.5 hours
- 3 - 4.5 hours
- 5 - 6.5 hours
- 7 - 8.5 hours
- greater than 9 hours
- Other

[]If any, choose any chronic illness that you may have

Please choose **all** that apply:

- heart disease
- cancer
- stroke
- diabetes
- no comment
- none of the above
- Other:

[]If applicable, select any of these health conditions that you may have

Please choose **all** that apply:

- Arthritis or joint problems
- Hypertension,
- Asthma, chronic bronchitis or emphysema

- Back or spine problems
- Osteoporosis
- Shortness of breath
- Dizziness or Light-headedness
- Chest pain
- Hearing issues
- Trouble seeing even with glasses or contact lenses
- Fractures (broken bones) such as hip fracture, compression fracture or spine fracture
- Body pain when moving around
- Would rather not say
- None of the above
- Other:

[[If applicable, please select any mental disorders that you may have

Please choose **all** that apply:

- depression
- anxiety disorders
- dementia
- none of the above
- would rather not say
- Other:

Physical Activity (PA) Questions-2

[[Select your inclination to participate in Physical Activity from an interest, motivation and ability perspective *

Please choose the appropriate response for each item:

	1 weak	2	3 neutral	4	5 strong
Select your level of INTEREST in participating in Physical Activity	<input type="radio"/>				
Select your level of MOTIVATION in participating in Physical Activity	<input type="radio"/>				
Select your level of ABILITY in participating in Physical Activity	<input type="radio"/>				

[[What is your Risk of Falling when doing simple activities such as walking, moving about the house or outside the house?

Please choose **only one** of the following:

- High
- Medium
- Low
- None of the above
- Other

[[What prevents you from participating in Physical Activity?

Please choose **all** that apply:

- Physical Barriers
- Mental Barriers
- Emotional Barriers
- None of the above
- Would rather not say
- Other:

[[Select one or more of the Physical Barriers from the list that prevents you from participating in Physical Activities *

Please choose **all** that apply:

- Disability
- Arthritis
- Pain
- Lack of skill
- Weather,
- Distance to gym

- Lack of time,
- Family obligations
- None of the above
- Other:

[]Select one or more of the Psychological Barriers that prevents you from participating in Physical Activities *

Please choose **all** that apply:

- fear of pain
- fear of failure
- fear of injury
- intimidation
- inconvenience
- boredom
- none of the above
- Other:

[]Select one or more of the Emotional Barriers that prevents you from participating in Physical Activities *

Please choose **all** that apply:

- lack of motivation
- lack of energy
- not enjoyable
- none of the above
- Other:

Physical Activity (PA) Questions-3

[]Select one or more of the Sociological Barriers that prevents you from participating in Physical Activities *

Please choose **all** that apply:

- peer pressure
- lack of companionship
- intimidated by group activities
- intimidated by presence of other people at the gym
- intimidated by other physically fit individuals
- none of the above
- Other:

[]How many hours in a day do you participate in Physical Activities? *

Please choose **only one** of the following:

- less than 30 minutes
- less than 45 minutes
- 1 hour
- 1 - 2½ hours
- 3 - 4½ hours
- greater than 5 hours

[]How many hours in a week do you participate in Physical Activities? *

Please choose **only one** of the following:

- Less than 1 hour
- 1 - 2½ hours
- 3 - 4½ hours
- 5 - 6½ hours
- 7 - 8½ hours
- greater than 9 hours

Do you participate in any of these activities on a weekly basis?

If so indicate the number of times and number of hours per day in the comment box
i.e. as an example, Number of times; Number of Hours (per day) could be indicated as 4;3
 Comment only when you choose an answer.

Please choose all that apply and provide a comment:

- walking
 - jogging
 - running
 - cross training
 - cardio exercises
 - cycling
 - swimming
 - none of the above
- Other:

[] Do you participate in any of these activities on a weekly basis?

**If so indicate the number of times and number of hours per day in the comment box
i.e. as an example, Number of times; Number of Hours (per day) could be indicated as 4;3
Comment only when you choose an answer.**

Please choose all that apply and provide a comment:

- gardening
- lifting
- bowling
- golf
- carpentry
- yoga
- shoveling snow
- none of the above

Other:

[] Do you participate in any of these activities on a weekly basis?

**If so indicate the number of times and number of hours per day in the comment box
i.e. as an example, Number of times; Number of Hours (per day) could be indicated as 4;3
Comment only when you choose an answer.**

Please choose all that apply and provide a comment:

- doing dishes
- dusting
- vacuuming
- sweeping
- moping the floor
- none of the above

Other:

Physical Activity (PA) Questions-4

[] Do you participate in any of these activities on a weekly basis?

**If so indicate the number of times and number of hours per day in the comment box
i.e. as an example, Number of times; Number of Hours (per day) could be indicated as 4;3
Comment only when you choose an answer.**

Please choose all that apply and provide a comment:

- train with a coach
- attend a health class
- go for a swim class
- attend a fitness class
- attend an aerobics class
- attend a dance class
- attend an aqua fit class
- none of the above

Other:

Over the past 7 days, how much time did you spend sitting on week day?

Please write your answer(s) here:

Number of hours per DAY

Number of minutes per DAY

Don't know (enter 0 in this field if there was no similar activity)

(This question is about the time you spent sitting on weekdays during the last 7 day. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.)

Think about the time you spent WALKING in the last 7 days

Over the past 7 days, how often did you take a walk outside your home or yard for any reason? For example, for fun or exercise, walking to work, walking the dog, walking in a mall, etc.?

Please write your answer(s) here:

Number of times per WEEK

Number of Hours (per DAY)

Number of Minutes (per DAY)

None (enter 0 in this field if there was no similar activity)

(This includes at work and at home, walking to travel from place to place, and any other walking that you might do solely for recreation, sport, exercise, or leisure. How many times did you walk for at least 10 minutes at a time?)

Over the past 7 days, how often did you engage in LIGHT sport or recreational activities such as bowling, golf with a cart, shuffleboard, fishing from a boat or pier or other similar activities?

Please write your answer(s) here:

Number of times in a WEEK

Number of Hours (per DAY)

Number of Minutes (per DAY)

None (enter 0 in this field if there was no similar activity)

Over the past 7 days, how often did you engage in MODERATE sport or recreational activities such as doubles tennis, ballroom dancing, hunting, ice skating, golf without a cart, softball or other similar activities?

Please write your answer(s) here:

Number of times in a WEEK

Number of Hours (per DAY)

Number of Minutes (per DAY)

None (enter 0 in this field if there was no similar activity)

Over the past 7 days, how often did you engage in STRENUOUS sport or recreational activities such as jogging, swimming, cycling, singles tennis, aerobic dance, skiing (downhill or cross country or other similar activities?

Please write your answer(s) here:

Number of times in a WEEK

Number of Hours (per DAY)

Number of Minutes (per DAY)

None (enter 0 in this field if there was no similar activity)

Physical Activity (PA) Questions-5

Over the past 7 days, how often did you do any exercises specifically to increase muscle strength or endurance, such as lifting weights or pushups, etc?

Please write your answer(s) here:

Number of times per WEEK

Number of Hours (per WEEK)

None (enter 0 in this field if there was no similar activity)

During the past 7 days, have you done any light housework, such as dusting, washing or drying dishes, or ironing?

Please write your answer(s) here:

Number of times per WEEK

Number of Hours (per WEEK)

None (enter 0 in this field if there was no similar activity)

During the past 7 days, have you done any heavy housework or chores such as vacuuming, scrubbing floors, washing windows, or carrying wood?

Please write your answer(s) here:

Number of times in a WEEK

Number of Hours (per WEEK)

None (enter 0 in this field if there was no similar activity)

[]During the past 7 days, did you engage in home repairs like painting, wallpapering, electrical work, etc.?

Please write your answer(s) here:

Number of times in a WEEK

Number of Hours (per WEEK)

None (enter 0 in this field if there was no similar activity)

[]During the past 7 days, did you engage in lawn work or yard care, including snow or leaf removal, chopping wood, etc?

Please write your answer(s) here:

Number of times in a WEEK

Number of Hours (per WEEK)

None (enter 0 in this field if there was no similar activity)

[]During the past 7 days, did you engage in outdoor gardening?

Please write your answer(s) here:

Number of times in a WEEK

Number of Hours (per WEEK)

None (enter 0 in this field if there was no similar activity)

Physical Activity (PA) Questions-6

[]During the past 7 days, did you engage in caring for another person such as a child, dependent spouse, or another adult?

Please write your answer(s) here:

Number of times in a WEEK

Number of Hours (per WEEK)

None (enter 0 in this field if there was no similar activity)

[]How many hours per week did you work for pay and/or as a volunteer?

Please write your answer(s) here:

Number of Hours (per week)

None (enter 0 in this field if there was no similar activity)

[]Which of the following categories best describes the amount of physical activity required on your job and/or volunteer work? *

Please choose **only one** of the following:

Category 1 (“Mainly sitting with slight arm movements”) includes examples such as office worker, watchmaker, seated assembly line worker, bus driver, etc.

Category 2 (“Sitting or standing with some walking”) includes examples such as cashier, general office worker, light tool and machinery worker.

Category 3 (“Walking, with some handling of materials generally weighing less than 50 pounds”) includes examples such as mailman, waiter/waitress, construction worker, heavy tool and machinery worker.

Category 4 (“Walking and heavy manual work often requiring handling of materials weighing over 50 pounds”) includes examples such as lumberjack, stonemason, farm or general laborer].

Other

Demographic Information

The following questions gather information about your background and current activities

[]

Please input your age

(Only numbers may be entered into this field) *

Only numbers may be entered in this field.

Please write your answer here:

[]What is your gender? *

Please choose **only one** of the following:

Female

Male

Other

Would rather not say

[]What is the highest degree or level of school you have completed? *If currently enrolled, select the highest degree received*

Please choose **only one** of the following:

No schooling completed

Nursery school to 8th grade

Some high school, no diploma

High school graduate, diploma or the equivalent (for example GED)

Some college credit, no degree

- Trade/technical/vocational training
- Bachelor's degree
- Master's degree
- Professional degree
- Doctorate degree
- Would rather not say
- Other

[] Employment Information

Please choose **only one** of the following:

- Employed for wages
- Self-employed
- Out of work and looking for work
- Out of work but not currently looking for work
- A homemaker
- A student
- Military
- Retired
- Unable to work
- Would rather not say
- Other

[] What is your current household income in Canadian dollars?

Please choose **only one** of the following:

- Under \$10,000
- \$10,000 - \$19,999
- \$20,000 - \$29,999
- \$30,000 - \$39,999
- \$40,000 - \$49,999
- \$50,000 - \$74,999
- \$75,000 - \$99,999
- \$100,000 - \$150,000
- Over \$150,000
- Would rather not say
- Other

[] Which of these types of these devices do you use most frequently?

Please choose **all** that apply:

- Smartphones
- Cell-phones
- Tablets
- Desktop computers
- Laptop computers
- All on the list
- Other:

Digital Gaming Experience (Video games, online digital games, games on smartphones/mobile devices)

This set of questions are about your digital gaming experience and skill level

[] Which of these devices do you use most frequently to play digital games? *

Please choose **only one** of the following:

- Smartphones
- Cell-Phones
- Tablets
- Desktop computers
- Laptop computers

- Game Consoles (XBox 360, Xbox One, PS3, PS4, Nintendo, Nintendo 3DS, Wii, Wii U)
- Online
- All on the list
- Other

[[Please select your inclination towards digital games *

Please choose **only one** of the following:

- Yes, I play a lot of digital games
- I am somewhat inclined
- I am moderately inclined
- I am inclined but I do know where to start
- No, I do not play any digital games

[[How many years of years of digital gaming experience do you have?

Please choose **only one** of the following:

- 0-1 years
- 1-8 years
- 9-15 years
- 16-20 years
- 21-25 years
- 25+ years
- None of the above

[[How would you rate your digital gaming experience level to be? *

Please choose **only one** of the following:

- Novice
- Intermediate
- Expert
- None of the above

[[How many hours of digital gaming do you log for digital gaming per week? *

Please choose **only one** of the following:

- less than 2 hours
- 2 - 4 hours
- 5 - 9 hours
- 10 - 15 hours
- 16 - 24 hours
- greater than 24 hours
- I do not play digital games

[[How many hours in a day do you spend using a Computer for other activities? *

Please choose **only one** of the following:

- Less than 1 hour
- 1 -2 hours
- 3 - 4 hours
- 5 - 6 hours
- 7 - 9 hours,
- greater than 9 hours
- Other

[[Select your preference of social networking sites.

All your answers must be different and you must rank in order.

Please number each box in order of preference from 1 to 6

- Facebook
- Pinterest
- Instagram
- LinkedIn
- YouTube

Flickr

Physical Activity Monitoring

The questions in this section relate to devices and elements used by you to monitor your daily physical activity

[]Do you use any of these devices to monitor activity during physical activity sessions? *

Please choose **only one** of the following:

- Heart Rate monitor
- Heart Rate watch,
- Pedometer
- FuelBand
- FitBit Flex
- Fitbit One
- I do not use any device
- Other

[]Do you use any of these apps to monitor your physical activities or physical activity sessions? *

Please choose **only one** of the following:

- Nike Plus
- Nike+Running
- GoogleFit
- SamsungHealth
- SuperBetter
- FitBit
- I do not use any device
- Other

[]Do you use any of these web portals to monitor your activities? *

Please choose **only one** of the following:

- Fitocracy
- FitOrbit
- UtiliFit
- GoogleFit
- I do not use any of these web portals
- Other

If you USE an app or a device when you participate in Physical Activities, what types of feedback do you look for when you use these devices/apps?

If you DO NOT USE an app or a device, what type of feedback information would you have liked to receive to help make your experience of participating in an activity a better experience?

Please write your answer here:

As an example: please list whether you look for speed to completion, step counters, distance, points, progression, calories, feedback information or other information which not indicated here.

[]Can you suggest any attributes in the app (fitness application on your smartphone or tablet) which could help you participate or motivate you to participate in physical activities? *

Please write your answer here:

As an example: please list whether you look for speed to completion, step counters, distance, points, progression, calories, feedback information or other information which not indicated here.

[]Can you suggest any attributes which are not a motivating factor to participate in Physical Activities? *

Please write your answer here:

As an example: please list whether you look for speed to completion, step counters, distance, points, progression, calories, feedback information or other information which not indicated here.

[]Can you suggest any attributes which could help you to decide on your goals for physical activity? *

Please write your answer here:

As an example: please list whether you look for speed to completion, step counters, distance, points, progression, calories, feedback information or other information which not indicated here.

[]Can you suggest any attributes which could help you continue to participate in physical activity sessions over a longer period of time? *

Please write your answer here:

As an example: please list whether you look for speed to completion, step counters, distance, points, progression, calories, feedback information or other information which not indicated here.

Confirmation

Thank you for completing the survey!

[]

Thank you for completing the survey!

You can stop at this point or continue to enter your information for the chance to win one of three \$30CDN Amazon.ca gift card (to the value of \$30CDN each, redeemable only at Amazon.ca; one chance per email address)

Would you like to continue?

*

Please choose **only one** of the following:

Yes

No

OPTIONAL: Enter your information for a chance to win one of three \$30 CDN Gift Cards from Amazon.ca

You can choose to enter your email address for a chance to win one of three \$30CDN, Amazon.ca gift card. If you are interested in entering the draw for the chance to win an Amazon.ca Gift Card, please enter your email address in the section below

Three gift cards will be awarded at the end of the study. Participants cannot enter multiple times to increase chances of winning more than one gift card. The winners will be drawn randomly between the participants who opted to enter their email address into the draw. The gift card will be emailed to the winning participants immediately after the draw.

Your odds of winning the prize is based on the number of individuals who participate in the study. We expect more than 30 individuals to participate in this study. If you would like to participate in this draw, please enter your e-mail address below. Information collected to draw for the prize will not be linked to the study data in any way, and this identifying information will be stored separately, then destroyed after the prize has been provided. Participation in this draw is optional. If you do not wish to participate, just leave this field blank and proceed to the next page. Your participation in the Optional Amazon Gift Card Draw will only be confirmed if you enter your e-mail address on this page.

[]

OPTIONAL: Would you like to submit your email address for the chance to win a \$30CDN Gift Card from Amazon.ca?

Only answer this question if the following conditions are met:

Answer was 'Yes' at question '60 [CONF]' (Thank you for completing the survey! You can stop at this point or continue to enter your information for the chance to win one of three \$30CDN Amazon.ca gift card (to the value of \$30CDN each, redeemable only at Amazon.ca; one chance per email address) Would you like to continue?)

Please write your answer here:

End of Survey

Thank you for taking the time to answer these questions. We will endeavour to post results of this survey on our website www.hcigames.com

[]Submit your Survey *

Only answer this question if the following conditions are met:

Answer was 'No' at question '60 [CONF]' (Thank you for completing the survey! You can stop at this point or continue to enter your information for the chance to win one of three \$30CDN Amazon.ca gift card (to the value of \$30CDN each, redeemable only at Amazon.ca; one chance per email address) Would you like to continue?)

Please choose **only one** of the following:

Yes

No

Thank you for participating in this survey. If you need more information about this survey, please feel free to contact us at email: dennis.kappen@humber.ca; len@uwaterloo.ca or pejman.mirza-babaei@uoit.ca.

You could review the progress of this survey study at our website www.hcigames.com where we will be posting information about results within 12 months of this survey study and future publications

07-18-2016 – 21:46

Submit your survey.

Thank you for completing this survey.

13.4.2 Participant Demographics

	Total Participants	(n=150)
	(1) 18-29 (17, 11.3%)	m=25.7, SD=2.54; (F=11, M=6)
	(2) 30-49 (58, 38.7%)	m=39, SD=5.85; (F=28, M=30)
	(3) 50-64 (43, 28.7%)	m=56.9, SD=3.9; (F=25, M=18)
	(4) 65+ (32, 21.3%).	m=71.9, SD=4.9; (F=11, M=21)
Sit in a day (hours)	Less than 30 minutes	0.7%
	Less than 45 minutes	1.4%
	1 - 2.5 hours	14.9%
	3 - 4.5 hours	23.0%
	greater than 5 hours	60.1%
Sleep hours in Day(hours)	Less than 1 hour	2.0%
	3 - 4.5 hours	0.7%
	5 - 6.5 hours	41.5%
	7 - 8.5 hours	54.4%
	greater than 9 hours	1.4%
Inclination to play digital games	I play lot of digital games	4.7%
	I am somewhat inclined	14.0%
	I am moderately inclined	24.0%
	I am inclined but I do know where to start	5.3%
	I do not play digital games	52.0%
Devices used to play digital games	Smartphones	35.0%
	Cell-Phones	11.7%
	Tablets	22.3%
	Desktop computers	9.7%
	Laptop computers	9.7%
	Game Consoles	7.8%
	Online	1.9%
	All on the list	1.9%
Physical activity per day	less than 30 minutes	16.0%
	less than 45 minutes	23.3%
	1 hour	28.0%
	1 - 2½ hours	27.3%
	3 - 4½ hours	5.3%
Apps to monitor physical activities	Nike+Running	2.9%
	GoogleFit	4.4%
	SamsungHealth	2.2%
	FitBit	19.1%
	I do not use any device	71.3%

	Total Participants	(n=150)
Devices to monitor physical activities	Heart Rate monitor	5.2%
	Heart Rate watch,	1.5%
	Pedometer	17.0%
	FitBit Flex	8.9%
	Fitbit One	6.7%
	I do not use any device	60.7%

Table 60: Survey Study - Participant Demographics

13.4.3 Scale Reliability

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Stress Management	60.1572	159.967	.639	.532	.895
Revitalization	59.6361	163.113	.734	.785	.892
Enjoyment	60.1856	157.917	.738	.788	.891
Challenge	61.0622	151.000	.803	.733	.887
Social Recognition	62.3789	159.942	.638	.677	.895
Affiliation	61.7089	159.729	.574	.456	.898
Competition	62.0589	158.761	.544	.621	.900
Health Pressures	61.7094	166.825	.396	.272	.907
Ill Health Avoidance	59.2828	170.954	.523	.695	.900
Positive Health	58.8183	174.861	.544	.623	.900
Weight Management	59.7089	165.366	.544	.673	.899
Appearance	60.1956	162.505	.649	.573	.895
Strength & Endurance	59.5106	165.188	.670	.648	.895

Nimbleness	59.4606	168.040	.583	.624	.898
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Table 61: Survey Study - Scale Reliability

13.4.4 Frequencies of Affordances Differentiated by Age-Groups

Age Category		Feedback Types			Cumulative Percent
		Frequency	Percent	Valid Percent	
1	Valid	achievement	1	2.0	2.0
		badges	2	3.9	3.9
		calories	8	15.7	15.7
		challenges	2	3.9	3.9
		choice	1	2.0	2.0
		cost	1	2.0	2.0
		distance travelled	2	3.9	3.9
		feedback	2	3.9	3.9
		goals	1	2.0	2.0
		heart rate	7	13.7	13.7
		levels	2	3.9	3.9
		motivation	1	2.0	2.0
		no monitoring	1	2.0	2.0
		points	4	7.8	7.8
		progression	4	7.8	7.8
		share button	3	5.9	5.9
		sleep cycle	2	3.9	3.9
		step counters	5	9.8	9.8
		time	1	2.0	2.0
		weight loss	1	2.0	2.0
	Total	51	100.0	100.0	
2	Valid	badges	4	3.6	3.6
		calories	20	18.2	18.2
		choice	2	1.8	1.8
		distance travelled	17	15.5	15.5
		feedback	2	1.8	1.8

		goals	4	3.6	3.6	44.5
		heart rate	9	8.2	8.2	52.7
		no monitoring	12	10.9	10.9	63.6
		points	4	3.6	3.6	67.3
		progression	12	10.9	10.9	78.2
		share button	2	1.8	1.8	80.0
		step counters	18	16.4	16.4	96.4
		time	3	2.7	2.7	99.1
		weight loss	1	.9	.9	100.0
		Total	110	100.0	100.0	
3	Valid	achievement	1	1.1	1.1	1.1
		badges	4	4.5	4.5	5.7
		breathing rate	2	2.3	2.3	8.0
		calories	9	10.2	10.2	18.2
		challenges	2	2.3	2.3	20.5
		choice	2	2.3	2.3	22.7
		cost	1	1.1	1.1	23.9
		distance travelled	1	1.1	1.1	25.0
		feedback	10	11.4	11.4	36.4
		goals	4	4.5	4.5	40.9
		heart rate	2	2.3	2.3	43.2
		levels	5	5.7	5.7	48.9
		motivation	1	1.1	1.1	50.0
		no monitoring	1	1.1	1.1	51.1
		points	15	17.0	17.0	68.2
		progression	1	1.1	1.1	69.3
		share button	1	1.1	1.1	70.5
		sleep cycle	4	4.5	4.5	75.0
		sound	1	1.1	1.1	76.1
		step counters	2	2.3	2.3	78.4
		time	17	19.3	19.3	97.7
		weight loss	2	2.3	2.3	100.0
		Total	88	100.0	100.0	
4	Valid	achievement	2	1.7	1.7	1.7
		badges	4	3.4	3.4	5.1

blood pressure	2	1.7	1.7	6.8
breathing rate	2	1.7	1.7	8.5
calories	17	14.5	14.5	23.1
challenges	3	2.6	2.6	25.6
choice	3	2.6	2.6	28.2
cost	2	1.7	1.7	29.9
device	2	1.7	1.7	31.6
distance travelled	17	14.5	14.5	46.2
goals	3	2.6	2.6	48.7
heart rate	10	8.5	8.5	57.3
no monitoring	2	1.7	1.7	59.0
points	4	3.4	3.4	62.4
progression	4	3.4	3.4	65.8
share button	2	1.7	1.7	67.5
sleep cycle	2	1.7	1.7	69.2
sound	2	1.7	1.7	70.9
speed	4	3.4	3.4	74.4
step counters	21	17.9	17.9	92.3
time	7	6.0	6.0	98.3
weight loss	2	1.7	1.7	100.0
Total	117	100.0	100.0	

Table 62: Survey Study - Feedback Types

Motivational Affordances						
Age Category		Frequency	Percent	Valid Percent	Cumulative Percent	
1	Valid	badges	5	11.4	11.4	11.4
		calories	1	2.3	2.3	13.6
		challenges	3	6.8	6.8	20.5
		compare with friends	2	4.5	4.5	25.0
		daily notifications	1	2.3	2.3	27.3
		device	1	2.3	2.3	29.5
		distance travelled	4	9.1	9.1	38.6
		feedback	1	2.3	2.3	40.9

		goals	4	9.1	9.1	50.0
		incentive	1	2.3	2.3	52.3
		motivation	1	2.3	2.3	54.5
		points	4	9.1	9.1	63.6
		progression	5	11.4	11.4	75.0
		share button	2	4.5	4.5	79.5
		speed	2	4.5	4.5	84.1
		step counters	3	6.8	6.8	90.9
		trailing feedback	1	2.3	2.3	93.2
		weight loss	3	6.8	6.8	100.0
		Total	44	100.0	100.0	
2	Valid	achievement	1	1.0	1.0	1.0
		badges	2	2.1	2.1	3.1
		blood pressure	2	2.1	2.1	5.2
		calories	10	10.4	10.4	15.6
		challenges	3	3.1	3.1	18.8
		choice	2	2.1	2.1	20.8
		coaching	1	1.0	1.0	21.9
		compare with friends	2	2.1	2.1	24.0
		competition	2	2.1	2.1	26.0
		daily notifications	7	7.3	7.3	33.3
		distance travelled	7	7.3	7.3	40.6
		feedback	2	2.1	2.1	42.7
		feel good	4	4.2	4.2	46.9
		goals	2	2.1	2.1	49.0
		good form	1	1.0	1.0	50.0
		heart rate	5	5.2	5.2	55.2
		incentive	2	2.1	2.1	57.3
		leaderboard	2	2.1	2.1	59.4
		levels	2	2.1	2.1	61.5
		motivation	3	3.1	3.1	64.6
		negative feedback	1	1.0	1.0	65.6
		no monitoring	12	12.5	12.5	78.1
		nutrition	1	1.0	1.0	79.2

		points	3	3.1	3.1	82.3
		progression	6	6.3	6.3	88.5
		step counters	8	8.3	8.3	96.9
		weight loss	3	3.1	3.1	100.0
		Total	96	100.0	100.0	
3	Valid	achievement	2	3.5	3.5	3.5
		badges	2	3.5	3.5	7.0
		calories	7	12.3	12.3	19.3
		choice	2	3.5	3.5	22.8
		compare with friends	1	1.8	1.8	24.6
		competition	1	1.8	1.8	26.3
		daily notifications	3	5.3	5.3	31.6
		distance travelled	7	12.3	12.3	43.9
		feedback	1	1.8	1.8	45.6
		goals	2	3.5	3.5	49.1
		narrative	1	1.8	1.8	50.9
		no monitoring	12	21.1	21.1	71.9
		progression	4	7.0	7.0	78.9
		sleep cycle	1	1.8	1.8	80.7
		sound	1	1.8	1.8	82.5
		speed	1	1.8	1.8	84.2
		step counters	4	7.0	7.0	91.2
		weight loss	5	8.8	8.8	100.0
		Total	57	100.0	100.0	
4	Valid	achievement	2	2.1	2.1	2.1
		badges	2	2.1	2.1	4.3
		breathing rate	3	3.2	3.2	7.4
		calories	6	6.4	6.4	13.8
		challenges	3	3.2	3.2	17.0
		choice	4	4.3	4.3	21.3
		compare with friends	2	2.1	2.1	23.4
		daily notifications	3	3.2	3.2	26.6
		distance travelled	10	10.6	10.6	37.2

feedback	2	2.1	2.1	39.4
good form	2	2.1	2.1	41.5
heart rate	7	7.4	7.4	48.9
incentive	3	3.2	3.2	52.1
interface	5	5.3	5.3	57.4
leaderboard	2	2.1	2.1	59.6
levels	1	1.1	1.1	60.6
narrative	9	9.6	9.6	70.2
no monitoring	6	6.4	6.4	76.6
points	4	4.3	4.3	80.9
progression	6	6.4	6.4	87.2
step counters	10	10.6	10.6	97.9
time	2	2.1	2.1	100.0
Total	94	100.0	100.0	
. Valid	75	100.0	100.0	100.0

Table 63: Survey Study - Motivational Affordances

Negative Attributes						
Age Category		Frequency	Percent	Valid Percent	Cumulative Percent	
1	Valid	points	2	22.2	22.2	22.2
		social sharing	3	33.3	33.3	55.6
		step counters	4	44.4	44.4	100.0
		Total	9	100.0	100.0	
2	Valid	badges	4	7.5	7.5	7.5
		calories	3	5.7	5.7	13.2
		challenges	9	17.0	17.0	30.2
		cost	1	1.9	1.9	32.1
		distance travelled	4	7.5	7.5	39.6
		gimmicks	1	1.9	1.9	41.5
		heart rate	2	3.8	3.8	45.3
		intimidating social behaviour	2	3.8	3.8	49.1
		metrics	2	3.8	3.8	52.8
		no motivation	2	3.8	3.8	56.6

		personal data	4	7.5	7.5	64.2
		points	1	1.9	1.9	66.0
		progression	3	5.7	5.7	71.7
		social sharing	3	5.7	5.7	77.4
		spam	2	3.8	3.8	81.1
		step counters	7	13.2	13.2	94.3
		weight loss	3	5.7	5.7	100.0
		Total	53	100.0	100.0	
3	Valid	calories	4	14.8	14.8	14.8
		challenges	5	18.5	18.5	33.3
		device	2	7.4	7.4	40.7
		distance travelled	2	7.4	7.4	48.1
		feedback	2	7.4	7.4	55.6
		levels	2	7.4	7.4	63.0
		no monitoring	3	11.1	11.1	74.1
		points	2	7.4	7.4	81.5
		step counters	5	18.5	18.5	100.0
		Total	27	100.0	100.0	
4	Valid	badges	2	2.2	2.2	2.2
		calories	3	3.3	3.3	5.6
		challenges	9	10.0	10.0	15.6
		compare with friends	2	2.2	2.2	17.8
		cost	2	2.2	2.2	20.0
		distance travelled	1	1.1	1.1	21.1
		feedback	3	3.3	3.3	24.4
		heart rate	6	6.7	6.7	31.1
		intimidating social behaviour	3	3.3	3.3	34.4
		no monitoring	6	6.7	6.7	41.1
		no motivation	5	5.6	5.6	46.7
		personal data	7	7.8	7.8	54.4
		points	3	3.3	3.3	57.8
		progression	8	8.9	8.9	66.7
		social sharing	7	7.8	7.8	74.4

	speed	4	4.4	4.4	78.9
	step counters	6	6.7	6.7	85.6
	time	13	14.4	14.4	100.0
	Total	90	100.0	100.0	
.	Valid	187	100.0	100.0	100.0

Table 64: Survey Study - Negative Attributes

Affordances that Facilitate PA						
Age Category			Frequency	Percent	Valid Percent	Cumulative Percent
1	Valid	achievement	2	5.9	5.9	5.9
		calories	3	8.8	8.8	14.7
		challenges	4	11.8	11.8	26.5
		choice	2	5.9	5.9	32.4
		distance travelled	3	8.8	8.8	41.2
		feedback	1	2.9	2.9	44.1
		goals	5	14.7	14.7	58.8
		no monitoring	2	5.9	5.9	64.7
		points	5	14.7	14.7	79.4
		progression	3	8.8	8.8	88.2
		step counters	4	11.8	11.8	100.0
			Total	34	100.0	100.0
2	Valid	achievement	3	3.6	3.6	3.6
		avatars	2	2.4	2.4	6.0
		badges	2	2.4	2.4	8.4
		calories	5	6.0	6.0	14.5
		challenges	12	14.5	14.5	28.9
		choice	2	2.4	2.4	31.3
		device	1	1.2	1.2	32.5
		feedback	4	4.8	4.8	37.3
		fun	3	3.6	3.6	41.0
		goals	10	12.0	12.0	53.0
		health	2	2.4	2.4	55.4
		heart rate	2	2.4	2.4	57.8

		interface	2	2.4	2.4	60.2
		motivation	2	2.4	2.4	62.7
		narrative	2	2.4	2.4	65.1
		no monitoring	6	7.2	7.2	72.3
		progression	8	9.6	9.6	81.9
		sound	1	1.2	1.2	83.1
		speed	5	6.0	6.0	89.2
		step counters	7	8.4	8.4	97.6
		time	2	2.4	2.4	100.0
		Total	83	100.0	100.0	
3	Valid	badges	3	4.7	4.7	4.7
		calories	3	4.7	4.7	9.4
		challenges	5	7.8	7.8	17.2
		choice	9	14.1	14.1	31.3
		feel good	3	4.7	4.7	35.9
		goals	6	9.4	9.4	45.3
		heart rate	4	6.3	6.3	51.6
		interface	3	4.7	4.7	56.3
		levels	4	6.3	6.3	62.5
		narrative	1	1.6	1.6	64.1
		no monitoring	2	3.1	3.1	67.2
		points	4	6.3	6.3	73.4
		progression	3	4.7	4.7	78.1
		speed	3	4.7	4.7	82.8
		step counters	5	7.8	7.8	90.6
		time	3	4.7	4.7	95.3
		weight loss	3	4.7	4.7	100.0
		Total	64	100.0	100.0	
4	Valid	achievement	3	2.7	2.7	2.7
		badges	9	8.0	8.0	10.7
		blood pressure	3	2.7	2.7	13.4
		calories	2	1.8	1.8	15.2
		challenges	8	7.1	7.1	22.3
		coach	3	2.7	2.7	25.0
		distance travelled	6	5.4	5.4	30.4

feedback	4	3.6	3.6	33.9
feel good	2	1.8	1.8	35.7
goals	10	8.9	8.9	44.6
health	3	2.7	2.7	47.3
heart rate	4	3.6	3.6	50.9
interface	4	3.6	3.6	54.5
levels	4	3.6	3.6	58.0
motivation	3	2.7	2.7	60.7
no monitoring	3	2.7	2.7	63.4
points	7	6.3	6.3	69.6
progression	9	8.0	8.0	77.7
quests	4	3.6	3.6	81.3
simple routines	6	5.4	5.4	86.6
sound	2	1.8	1.8	88.4
speed	3	2.7	2.7	91.1
step counters	6	5.4	5.4	96.4
time	2	1.8	1.8	98.2
weight loss	2	1.8	1.8	100.0
Total	112	100.0	100.0	
. Valid	73	100.0	100.0	100.0

Table 65: Survey Study - Affordances that Facilitate PA

Attributes for Continuance of PA

Age Category	Frequency	Percent	Valid Percent	Cumulative Percent
1 Valid	badges	6	16.2	16.2
	calories	2	5.4	21.6
	challenges	4	10.8	32.4
	form	2	5.4	37.8
	goals	6	16.2	54.1
	motivation	2	5.4	59.5
	no monitoring	4	10.8	70.3
	points	4	10.8	81.1
	progression	5	13.5	94.6
	speed	2	5.4	100.0

		Total	37	100.0	100.0	
2	Valid	badges	5	8.9	8.9	8.9
		calories	4	7.1	7.1	16.1
		challenges	5	8.9	8.9	25.0
		cost	1	1.8	1.8	26.8
		feedback	3	5.4	5.4	32.1
		feel good	3	5.4	5.4	37.5
		fun	2	3.6	3.6	41.1
		goals	4	7.1	7.1	48.2
		no monitoring	2	3.6	3.6	51.8
		progression	6	10.7	10.7	62.5
		share	5	8.9	8.9	71.4
		speed	4	7.1	7.1	78.6
		step counters	6	10.7	10.7	89.3
		time	6	10.7	10.7	100.0
		Total	56	100.0	100.0	
3	Valid	badges	4	7.3	7.3	7.3
		calories	4	7.3	7.3	14.5
		device	2	3.6	3.6	18.2
		distance travelled	3	5.5	5.5	23.6
		feedback	5	9.1	9.1	32.7
		feel good	4	7.3	7.3	40.0
		goals	7	12.7	12.7	52.7
		motivation	2	3.6	3.6	56.4
		no monitoring	3	5.5	5.5	61.8
		points	3	5.5	5.5	67.3
		progression	5	9.1	9.1	76.4
		quests	2	3.6	3.6	80.0
		speed	2	3.6	3.6	83.6
		step counters	6	10.9	10.9	94.5
		weight loss	3	5.5	5.5	100.0
		Total	55	100.0	100.0	
4	Valid	badges	4	4.7	4.7	4.7
		breathing rate	4	4.7	4.7	9.3
		calories	2	2.3	2.3	11.6

challenges	2	2.3	2.3	14.0
choice	3	3.5	3.5	17.4
distance travelled	5	5.8	5.8	23.3
feedback	13	15.1	15.1	38.4
feel good	3	3.5	3.5	41.9
fun	2	2.3	2.3	44.2
goals	11	12.8	12.8	57.0
health	2	2.3	2.3	59.3
heart rate	2	2.3	2.3	61.6
interface	2	2.3	2.3	64.0
no monitoring	2	2.3	2.3	66.3
points	3	3.5	3.5	69.8
progression	12	14.0	14.0	83.7
quests	2	2.3	2.3	86.0
share	3	3.5	3.5	89.5
speed	2	2.3	2.3	91.9
step counters	3	3.5	3.5	95.3
weight loss	4	4.7	4.7	100.0
Total	86	100.0	100.0	
Valid	132	100.0	100.0	100.0

Table 66: Survey Study - Attributes for Continuance of PA

13.5 Comparison of Gamified Technology for PA

Gamified Fitness App	Gadget	Rules	Actions	Challenges	Intrinsic Motivation Elements	Extrinsic Motivation Elements	Tailored to Older Adults	Device	Platforms
Fitbit	Fitbit Flex (on wrist)	Challenge individually or your group		Weekend Warrior, Daily Show Down, Workweek Hustle	Improve health, improve skill	cheers taunts updates measure achievements against challenges	no	Wearable	Android iOS
Fitbit One	One (clip on clothing)	separates step goal, separate distance separate calories as goals	Steps, distance, calories burned, stairs climbed and track sleep	Daily progress achievements (reaching goals)	Improve health, share health, PA status	points achievement levels leaderboards building community	no	Smartphone tablet computer	Fitbit-Dashboard
Nike+	Fuel band	Set own goals, set challenges individual and group	Tracks steps, calories, distance	Unlock Achievements using NikeFuel points, Nike missions	Improve Relatedness, Social	NikeFuel Points Nike+ Leaderboards (compare NikeFuel)	no	"Smartphone tablet computer"	Android iPhone App via BlueTooth
Nike+ Running	iPhone App	running counter	tracking running distance calories levels		Relatedness-Social	FuelPoints, Leaderboards Compare with others	no	Smartphone tablet computer	iPhone App via BlueTooth
Fitocracy	Online Training App	Select from pool of exercise activities, logging exercise activity	Join groups, join forums	achievements to collect, quests difficulty levels (3 levels), prerequisites for certain activities	Competence relatedness-Social	Points based on fitness benefits, level up, community following, props and likes from community	no	Smartphone tablet computer	iPhone Android
Spirit50	Online Training App for 50+ age group	Select from pool of exercise activities, logging exercise activity	Select long-term goals, barriers and challenges	Goal selection based on ability, difficulty levels (3 levels) prerequisites for certain activities, difficulty levels	Improve health, improve skill	Stars, points, accolades, progression meter	Yes: customized for current fitness health, barriers and goals		Laptop, desktop

13.6 Personality Attributes from Preliminary Studies

Interestingly, the findings from qualitative interviews and informal focus group sessions (Section 5.5) indicated congruence in many thematic areas. The above findings from interviews and informal focus groups indicate the relevance of motivation related to initial engagement, retaining interest, and sustaining focus on fitness activities. Results demonstrated that motivation in older adults engaged in fitness activity was essentially internalized, and driven by intrinsic motivation. From the interviews, need satisfaction was determined to be a high priority for older adults in intrinsically motivated thematic areas of engagement, performance, and achievement for the competence dimension; purpose, independence, and customization themes in the autonomy dimension; and themes of relationships, sharing, and preferences in the relatedness dimension. The need to experience positive emotion, overcome fears of a sedentary lifestyle, and improve energy levels facilitated the introjections, identification, and titration dimensions of extrinsic motivation. Many older adult participants indicated that instant gratification was not important, implying that a tangible visible reward was not as important for older adults when compared with teenagers or younger adults. At the same time, receiving praise, being commended for their performance by their PT, and earning bragging rights for capability in performing fitness activities fueled self-determined extrinsic motivation. The desire of older adults to communicate with others about their own activities, be empathic towards others' health situations, co-operate and compete, and even help one another through encouragement and advice fostered reliance on co-participants in social fitness activities.

The guideline for the Motivated Behaviour Layer (MBL) of the *Kaleidoscope of Effective Gamification* (Kappen & Nacke, 2013) proposes the determination of intrinsic and extrinsic motivational characteristics prior to establishing any design language for a business application (in this case, a gamified online fitness application for older adults). From the perspective of gamified fitness, I am interested in the personalities of older adults in association with fitness activities, to be akin to player behaviour in relation to the game mechanics of a multi-user game. Our exploratory inquiry into the motivations of older adults through interviews and focus groups informed us about varied personality characteristics of older adults in the context of fitness activities.

While in-game challenges are imposed by game mechanics and other players, fitness challenges are imposed by the physical and mental condition of the player themselves. These individual challenges and impairments become pre-conditions to participating in gameplay. Achievers, explorers, socializers, and killers (imposers) (Bartle, 1990) were personality characteristics of players immersed in a game environment as determined by their use of game mechanics to advance in the game. Older adults' personality characteristics related to fitness activity can be presented in the following exploratory taxonomy model, which I explain in the following paragraphs.

Personality	Key Characteristic
Coward	Reluctant to take risks
Doubter	Fearful of activities with lack of confidence
Inquisitor	Investigative, interested in finding information only
Explorer	Participates in exploratory fitness steps
Nudgee	Needs someone to nudge them toward more fitness activities
Socializer	Sharing and vivacious individual
Achiever	Athlete with accountability
Maverick	Willing to try anything
Needer	Requires continuous assistance

Table 67 Taxonomy of Personality Attributes

Coward

A few participants were reluctant to take risks because they lacked the courage to initiate physical activity. They were afraid of the dangers of falling due to limitations imposed by age-related challenges. These obstacles stemmed from barriers posed by infirmities, sedentary lifestyles, and general apprehensions regarding exercise, which was considered to be a dangerous activity.

Doubter

Some participants were afraid of failing and lacked the confidence in their skills to be able to engage in a fitness PA. A few participants expressed reluctance in even considering the

possibility of trying out any fitness routine for fear of failure and inability to meet the expectations of the fitness routine and PT. PF1 said “[...] earlier I did not want to join because I was afraid of failing and being unable to meet the goals until I met a PT who gave me the confidence [...].”

Inquisitor

A few participants were keen only in obtaining information about the fitness activities. As mentioned by PF1, “[...] a few of my friends go to many fitness centers and bring back lots of information, but never join; I am hoping that I could inspire them to join by my actions.”

Explorer

Some participants were interested in increasing their activity levels to overcome sedentary tendencies and improve their lifestyles. One participant was fearful of becoming immobile like his parents and hence began to explore simple fitness routines. Participant P2 said “[...] I am afraid of becoming immobile like my mother [...], hence I am trying out different simple activity routines.”

Nudgee

Some participants had already overcome the reluctance to take risks in initiating fitness activity routines. However, there was an incessant feeling of lack of energy (Participant P4 said “[...] even though I have started the exercises, my energy levels are low and the presence of someone to push me to exercise is always good, it helps me believe in myself.”) The presence of a PT or a friend to encourage or “prod” them to continue to exercise became a characteristic of some individuals who needed the push to continue their active lifestyle.

Socializer

Three participants engaged in fitness activities purely for the opportunity to indulge in social connections and relationships afforded by the presence of others. The presence of others in a fitness activity group allowed the possibility of sharing experiences, encouraging one another, and establishing mutual respect for one another’s challenges. Participant P6 said “[...] I like it that my colleagues at the center understand my health challenges but still encourage me with small successes [...] which tells me that they care.”

Achiever

Three participants were keen on competing with one another and even engaged in collaborative team fitness challenges. This allowed us to understand behaviours resulting from competitive traits and co-operation in team fitness activities. Participant PF2 said “[...] *Team tracking or activity with others helps with the competitive spirit [...], and helps with the feeling of group activity and combined effort.*”

Maverick

A couple of participants tried their hand at many different types of fitness activities as the opportunity presented itself. One participant (P5) tried line dancing, yoga, and tai-chi during the same fitness week, as she was excited about trying out new types of activities. The participant noted that “[...] *I get bored with one type of activity very quickly; hence I prefer to do multiple types of fitness activities so that I can maintain interest all the time.*”

Needy

Two participants, while maintaining an active lifestyle, needed the presence of a PT or a nurse to help with their fitness activities because of their physical condition and a lack of trust in their ability to overcome physical challenges on their own. P8 said, “[...] *even though I know the exercise routines, I feel that the presence of a PT gives me the confidence to continue to work hard, knowing that the PT would be available to help if something went wrong.*”

The above taxonomy of personality characteristics of older adults’ attitudes towards fitness activities helps us understand *active lifestylers*, and customize fitness gamification applications for specific target audiences. Motivational inclinations can be tailored to meet the needs and expectations of specific personalities within the *active lifestyler* group.

13.7 Phase 4: International Physical Activity Questionnaire (IPAQ)

Project: Gamification Application and User Study
HUMBER COLLEGE: REB#0334; UOIT-REB# 15-053

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE (October 2002) - LONG FORM - LAST 7 DAYS SELF-ADMINISTERED FORMAT, FOR USE WITH YOUNG AND OLDER ADULTS (15-69 years)

The International Physical Activity Questionnaires (IPAQ) comprises a set of 4 questionnaires. Long (5 activity domains asked independently) and short (4 generic items) versions for use by either telephone or self-administered methods are available. The purpose of the questionnaires is to provide common instruments that can be used to obtain internationally comparable data on health-related physical activity.

Background on IPAQ

The development of an international measure for physical activity commenced in Geneva in 1998 and was followed by extensive reliability and validity testing undertaken across 12 countries (14 sites) during 2000. The final results suggest that these measures have acceptable measurement properties for use in many settings and in different languages, and are suitable for national population-based prevalence studies of participation in physical activity.

Using IPAQ

Use of the IPAQ instruments for monitoring and research purposes is encouraged. It is recommended that no changes be made to the order or wording of the questions as this will affect the psychometric properties of the instruments.

Translation from English and Cultural Adaptation

Translation from English is encouraged to facilitate worldwide use of IPAQ. Information on the availability of IPAQ in different languages can be obtained at www.ipaq.ki.se. If a new translation is undertaken we highly recommend using the prescribed back translation methods available on the IPAQ website. If possible please consider making your translated version of IPAQ available to others by contributing it to the IPAQ website. Further details on translation and cultural adaptation can be downloaded from the website.

Further Developments of IPAQ

International collaboration on IPAQ is on-going and an International Physical Activity Prevalence Study is in progress. For further information see the IPAQ website.

More Information

More detailed information on the IPAQ process and the research methods used in the development of IPAQ instruments is available at www.ipaq.ki.se and Booth, M.L. (2000). Assessment of Physical Activity: An International Perspective. *Research Quarterly for Exercise and Sport*, 71 (2): s114-20. Other scientific publications and presentations on the use of IPAQ are summarized on the website.

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the last 7 days. Please answer each question even if you do not consider yourself to be an active person. Please

think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the vigorous and moderate activities that you did in the last 7 days. Vigorous physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Moderate activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal.

PART 1: JOB-RELATED PHYSICAL ACTIVITY

The first section is about your work. This includes paid jobs, farming, volunteer work, course work, and any other unpaid work that you did outside your home. Do not include unpaid work you might do around your home, like housework, yard work, general maintenance, and caring for your family. These are asked in Part 3.

1. Do you currently have a job or do any unpaid work outside your home?

Yes

No Skip to PART 2: TRANSPORTATION

The next questions are about all the physical activity you did in the last 7 days as part of your paid or unpaid work. This does not include traveling to and from work.

2. During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, heavy construction, or climbing up stairs as part of your work? Think about only those physical activities that you did for at least 10 minutes at a time.

_____ days per week

No vigorous job-related physical activity Skip to question 4

3. How much time did you usually spend on one of those days doing vigorous physical activities as part of your work?

_____ hours per day

_____ minutes per day

4. Again, think about only those physical activities that you did for at least 10 minutes at a time.

During the last 7 days, on how many days did you do moderate physical activities like carrying light loads as part of your work? Please do not include walking.

_____ days per week

No moderate job-related physical activity Skip to question 6

5. How much time did you usually spend on one of those days doing moderate physical activities as part of your work?

_____ hours per day

_____ minutes per day

6. During the last 7 days, on how many days did you walk for at least 10 minutes at a time as part of your work? Please do not count any walking you did to travel to or from work.

_____ days per week

No job-related walking Skip to PART 2: TRANSPORTATION

7. How much time did you usually spend on one of those days walking as part of your work?

_____ hours per day

_____ minutes per day

PART 2: TRANSPORTATION PHYSICAL ACTIVITY

These questions are about how you traveled from place to place, including to places like work, stores, movies, and so on.

8. During the last 7 days, on how many days did you travel in a motor vehicle like a train, bus, car, or tram?

_____ days per week

No traveling in a motor vehicle Skip to question 10

9. How much time did you usually spend on one of those days traveling in a train, bus, car, tram, or other kind of motor vehicle?

_____ hours per day

_____ minutes per day

Now think only about the bicycling and walking you might have done to travel to and from work, to do errands, or to go from place to place.

10. During the last 7 days, on how many days did you bicycle for at least 10 minutes at a time to go from place to place?

_____ days per week

No bicycling from place to place Skip to question 12

11. How much time did you usually spend on one of those days to bicycle from place to place?

_____ hours per day

_____ minutes per day

12. During the last 7 days, on how many days did you walk for at least 10 minutes at a time to go from place to place?

_____ days per week

No walking from place to place Skip to PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY

13. How much time did you usually spend on one of those days walking from place to place?

_____ hours per day

_____ minutes per day

PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY

This section is about some of the physical activities you might have done in the last 7 days in and around your home, like housework, gardening, yard work, general maintenance work, and caring for your family.

14. Think about only those physical activities that you did for at least 10 minutes at a time. During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, chopping wood, shoveling snow, or digging in the garden or yard?

_____ days per week

No vigorous activity in garden or yard Skip to question 16

15. How much time did you usually spend on one of those days doing vigorous physical activities in the garden or yard?

_____ hours per day

_____ minutes per day

16. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the last 7 days, on how many days did you do moderate activities like carrying light loads, sweeping, washing windows, and raking in the garden or yard?

_____ days per week

No moderate activity in garden or yard Skip to question 18

17. How much time did you usually spend on one of those days doing moderate physical activities in the garden or yard?

_____ hours per day

_____ minutes per day

18. Once again, think about only those physical activities that you did for at least 10 minutes at a time. During the last 7 days, on how many days did you do moderate activities like carrying light loads, washing windows, scrubbing floors and sweeping inside your home?

_____ days per week

No moderate activity inside home Skip to PART 4: RECREATION, SPORT AND

LEISURE-TIME PHYSICAL ACTIVITY

19. How much time did you usually spend on one of those days doing moderate physical activities inside your home?

_____ hours per day

_____ minutes per day

PART 4: RECREATION, SPORT, AND LEISURE-TIME PHYSICAL ACTIVITY

This section is about all the physical activities that you did in the last 7 days solely for recreation, sport, exercise or leisure. Please do not include any activities you have already mentioned.

20. Not counting any walking, you have already mentioned, during the last 7 days, on how many days did you walk for at least 10 minutes at a time in your leisure time?

_____ days per week

No walking in leisure time Skip to question 22

21. How much time did you usually spend on one of those days walking in your leisure time?

_____ hours per day

_____ minutes per day

22. Think about only those physical activities that you did for at least 10 minutes at a time. During the last 7 days, on how many days did you do vigorous physical activities like aerobics, running, fast bicycling, or fast swimming in your leisure time?

_____ days per week

No vigorous activity in leisure time Skip to question 24

23. How much time did you usually spend on one of those days doing vigorous physical activities in your leisure time?

_____ hours per day

_____ minutes per day

24. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the last 7 days, on how many days did you do moderate physical activities like bicycling at a regular pace, swimming at a regular pace, and doubles tennis in your leisure time?

_____ days per week

No moderate activity in leisure time Skip to PART 5: TIME SPENT SITTING

25. How much time did you usually spend on one of those days doing moderate physical activities in your leisure time?

- _____ hours per day
- _____ minutes per day

PART 5: TIME SPENT SITTING

The last questions are about the time you spend sitting while at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading or sitting or lying down to watch television. Do not include any time spent sitting in a motor vehicle that you have already told me about.

26. During the last 7 days, how much time did you usually spend sitting on a weekday?

- _____ hours per day
- _____ minutes per day

27. During the last 7 days, how much time did you usually spend sitting on a weekend day?

- _____ hours per day
- _____ minutes per day

This is the end of the questionnaire, thank you for participating

13.8 Phase 4: Sample Participant Responses for the Discussion Section

13.8.1 Motivation for PA

Group	Participant	Week	Sample Participant Responses
G1	P08	2,5,8	"...what makes me happy is, with the app, because I wanted to do it, I went and did it and when it's done, it makes me happy..." ; "like I said, when I get that urge, I don't mind what I see here (in the app), and I'll do it"; "...that, hey I got to the top of the stairs and I wasn't going on gasping for breath..."; "...Well, it has definitely sparked a...what do you say(?)...you should do more attitude. It definitely did...;
G1	P16	5,7	"...I did all sessions of the website..."; "...felt happy after being able to complete my exercises this week";
G1	P24	8	"I do feel good that I came to this place and used the app, and it helps to see what to do in the going forward."
G1	P26	3,6	"...I believe that once I've started it I wanted to see through this entire eight-week program..."; "...Felt happy to be consistent with the site..."
G1	P31	5	"It helps to add upper body strength routine which I was unaware of and I felt like trying to doing more"
G2	P02	3, 5	"...need to take care of my body more and do more..."; "...full stomach feeling, low energy forcing to do more"
G2	P05	3	"...the more you do the better it looks...we have a place up north and we want it to look nice...and during the winter ...u cannot do anything outside, during fall or spring it is usually muddy..."; "...so it's interesting because at least at the same time it gives you feedback the number of steps..."
G2	P18	7	"...Just wanted to work hard..."; "...wanted to train more..."
G2	P21	1	"... wanted to up that mark and would have been wonderful to get up that ..."

Group	Participant	Week	Sample Participant Responses
G2	P23	5	“so...it's interesting because at least at the same time it (pedometer) gives you feedback the number of steps and also the inclination and the type of thing and heart rate uninteresting and some stats like that”; “...I have gone from 500 to 15000 and ever since the start of this session with you... so interesting... thank you for the inspiration...”; “...the framing of what I'm doing as a goal (steps to meet), it's just like different... I never had framed is like a goal...ever since we started these sessions I started looking at these as goals...”
G3	P25	3	“...cleaning and grouting the driveway (interlocking) it was a lot of tedious work...”
G3	P27	1	“...now I can do things the way I can, do it by one time, any time at my own pace due to retirement...”

Table 68: Participant Responses - Accomplishing a Goal

Group	Participant	Week	Sample Participant Responses
G1	P04	5	“...I need begin to think of who is that old fart over there... you guys all slouched over so who's this... and then I realize it is myself I am.... “; “...doing the app forces a sense of routine...virtually...”
G1	P08	1	“...it (study) was interesting because of the age bracket...so I signed up...”
G1	P10	2	“...I realize that with age certain things change. But I had a different, mental scale to suggest how many good years do I have left, with optimal health...”
G1	P24	1	“...hoping to prevent old age...”

Table 69: Participant Responses - Aging Well

Group	Participant	Week	Sample Participant Responses
G1	P04	5	“...I am 72 now and it was a terrible birthday because I have to take my wife to the hospital and my son shares the birthday one day earlier than mine, but we have a combined collective birthday.... but (cake) it is still there like in the freezer....”

Group	Participant	Week	Sample Participant Responses
G1	P08	2,4,5	"...if I feel like doing some work that leads to physical activity, that's what I love to do ..."; "...so, I'm fact that I'm engaging in this (app activity), I can probably do more but when I don't feel well or I'm not mentally or physically not in the mood I'm not sure about that..."; "... all these exercises (app), I'm feeling it, I'm feeling it it's not complex by leaps and bounds, but it's definitely like a big realization..."; "...you know when it says take a day off.... go here... or rest... I did not ...went on doing it for more time..."
G1	P10	6	"...as far as breaking it (app exercises) up into small manageable pieces and rotating through them at a rapid pace...nothing over an hour..."
G1	P11	3,8	"...I do have a number of things to do, but, I see that I have make to make sure that I can fit it (app exercises) in..."; "...I did stretching (app exercises) a number of days... and the exercises... so you know perhaps it was overworking or overdoing from my side, which would have led to this sudden need of "me" time."; "...but I guess the key is to be true to yourself and the and try and do what is possible within the time frame..."
G1	P16	4,7	"...this week I felt that the higher intensity exercises for better for me..."; "...A few new exercises felt challenging and I was happy to try them out..."
G1	P24	3	"...that is what I mean by intrinsically lazy... so there is something that is for me to do first or overcome first before I do something or anything about it... so these simple exercises (from app) helps ..."; "...why... I did do a few things from the Spirit50, but, I did a few times, I also skipped my regular exercises..."
G1	P26	4	"...the challenge to see something through (eight-weeks) is ...it is a strong motivator ..."
G1	P29	3,5	"...so, this is good but this should be a combination of flexibility and strengthening..."; "...so it was there it was some variety in the choice of the selection...not in all...but, the change in some of these activities (app exercises) ...was good"
G1	P31	1,5	"...may be too much on the hike for me if I do not prepare by walking now..."; "...what I had decided was today, because, I know I had a busy day coming up, I would ...I would do this (app) as soon as I got up in the morning so that was kind of out of the way..."

Group	Participant	Week	Sample Participant Responses
G2	P05	2	"...but If somebody calls me and says to me let's play tennis, i.e. that is a challenge, I need to first check my schedule and then I would go if the schedule permits...and I really enjoy tennis and I would do that again..."
G2	P18	3	"...decided to add more walking (pedometer)..."
G2	P23	1, 2	"...so, this is so low... (laughs) hey ...I need to up my game here...."; "...I think for me it's good, it's getting a bit hard because I'm trying to push myself to go over the hills and now that I'm in the zone of doing this I feel like doing more (due to pedometer count) so I'm getting quite out of breath and I'm pushing myself..."
G3	P25	3	"...wanted to train for the half marathon..."
G3	P27	1	"...so, this past week I would say yes, you been pushed to go out and work more because they're talking about..."; "...motivation because of the twelve kilometers you're doing..."

Table 70: Participant Responses - Challenged by an Activity

Group	Participant	Week	Sample Participant Responses
G1	P01	1	"...here is a commitment towards the personal trainer who comes to see you...but, this can act as a virtual coach..."
G1	P08	3	"...I could do this anywhere (with app) ..."
G1	P10	2	"...often time when I make up my own schedule... fitness routines and exercises, I am far less rigorous in my motivation....."; "...I am going to hire a fitness person from H College, and a yoga person..."
G1	P24	1	"...but I do stretching exercises (from app) right in the middle of the living room, if somebody else is watching TV I just do my stretching right there and other than the gym because at the gym it's kind of dirty at the gym, so it's easier to do it at home that is clean.... I do a lot of floor stretches at home..."
G1	P29	2	"...I exercise in the gym 3 times a week, but, these exercises (from web application) I do I can do at home, or anywhere, from anywhere..."

Table 71: Participant Responses - Easy Access to Resources

Group	Participant	Week	Sample Participant Responses
G1	P04	5	"...6 times in a row I had to climb in and out of the boat just to organize the tank and pump fuel..., this was like doing the app exercises over and over again and tiresome..."

Group	Participant	Week	Sample Participant Responses
G1	P08	3,5	"...love taking care of the yard...which was a mess and did it because I felt like doing it...; and, the raking was a lot of lifting, bending stretching, similar to the ones (exercises) we have done in Spirit50..."; "...each day all the two-day weekend, bending scooping, raking changing urns... probably four hours each day eight hours in total..."; "...I'm doing something and the by-product is the exercise I don't like exercise..."
G1	P31	8	"...it's not reading much nowadays because I'm doing one of these other, the app or ... other activities, so I'm reading less but I don't mind..."
G2	P05	3	"...so, it was non-stop physical activity...and I was with one of my kids and I said that O my god we are tired exhausted... I'm going to be sore..., but I added to my step count (pedometer)"
G3	P25	2	"...went golfing and running..."
G3	P27	2	"...if you think of a way you find something that is missing... so what we do is, we take all the factors into account in summer; today I've been doing running for the past few weeks...and, I decided not to go for any Running today..."

Table 72: Participant Responses - Enjoying Outdoors

Group	Participant	Week	Sample Participant Responses
G1	P01	1	"...feel better when doing a regular routine (on app) or moving around..."
G1	P08	3,5	"...feel like the need to keep energy levels up...and I do the flex exercises (app)"; "...all these exercises I'm feeling it, I'm feeling it it's not complex by leaps and bounds, but it's definitely like a big realization..."
G2	P02	2	"...feel better about myself and keep my stress levels down...and walked to feel like doing something (pedometer step count)"
G2	P05	2	"...Just wanted to be energetic and feel that I am active (step count, time) and I can be active as in the past"
G2	P23	4	"...I feel it's always important for me to have that routine...and feels good to see numbers (pedometer)"

Table 73: Participant Responses - Experiences

Group	Participant	Week	Sample Participant Responses
G1	P01	1	"...afraid of getting stale, and therefore I did a few things (from app) ..."
G1	P04	1	"...afraid of not able to do anything, but these (app routines) are simple to do..."
G1	P11	3	"...nobody has died of lack of stretching exercises ...but have died of more severe health conditions, therefore I walk a lot to add more daily steps and time..., but I do the app stuff before and after my walk to loosen up... "
G1	P16	6	"...It made me aware of what I was missing (lack of strength, the app) ..."
G1	P31	2,6	"...afraid of not be able to walk on the hike if I do not walk everyday..."; "...now I do the routines (app) daily...because these are simple and easy to remember...and makes me overcome my stiffness..."
G2	P18	3	"...sitting at one place for most of the day was a sick feeling for me and so had to do exercise...and move around..."
G3	P15	1	"...if I'm not active I feel I'm unfit...and afraid of my future..."
G3	P25	1	"...also, illnesses is... that's another factor"

Table 74: Participant Responses - Fear of Being Unhealthy

Group	Participant	Week	Sample Participant Responses
G1	P08	2	"...so, losing weight is second reason, if I can do something that is exciting (simple app things) that can lead to losing weight is my biggest advantage..."
G1	P11	3,8	"...need ...an even more, tempered body...and the app can help me do these anytime "; "...I've noticed my weight is in a place that I am that I don't want it to increase... it (app) is some sort of an incentive to let's get moving and do some physical activity..."
G1	P16	3	"...but then you do not want everyone else to see that, just to say that I have done better, my arm looks less flabby... over the past 3 weeks (of doing the app) your muscle tone is increased or improved ..."
G1	P24	1,8	"...I hate it when my belly is hanging out...I was a gymnast...and these flex exercises only helps to do this anywhere..."; "...other than the fact that now that I have invested. I feel I have invested now, effort and time and I've got results, very satisfying results..."

Group	Participant	Week	Sample Participant Responses
G1	P31	2,6	"...afraid of not be able to walk on the hike if I do not walk everyday..."; "...now I do the routines (app) daily...because these are simple and easy to remember...and makes me overcome my stiffness..."
G2	P02	2	"...loose weight and increase energy levels ...walk more to do this the steps (pedometer) helps..."; "...summer weather, less clothes to hide behind, walk more and feel better overall..."
G2	P13	5	"...weight loss and toning...added a lot more steps"
G2	P18	2, 5	"...My motivation was to shed some fat..."; "...I have been putting more steps...I want to drop a few lbs before going on summer vacation to Mexico..."

Table 75: Participant Responses - Focussing on Appearances

Group	Participant	Week	Sample Participant Responses
G1	P08	2	"...I felt the excitement of scratching all items off the list (checkmark in app), main thing is really done, is the reward for me to do more..."
G1	P11	1,2	"...(I) write down all tracking information (weight, steps, time, distance) ..."; "...motivated by rewards (feeling good, energy levels, good health) ..."; "...motivated by rewards (step counts, time) ..."; "...I do not mind badges...points, seen in the app";
G1	P16	3,5,6	"...I noticed the points and the badges on the site and it was good to earn some, not that it mattered..."; "...Interested in knowing if I could do more to push the points up..."; "...Crossed the 1500 points mark, made me conscious of the points now..."
G1	P24	3	"...once in a while as you go along if you throw it in (slogans, images) ...so that the user of the app internalizes them and feels have some images, have inspirational imagery with it like, like the eagle, color of course, and inspiration to those things become a goal..."
G1	P29	5,7	"...I am not too crazy about the points and the badges, but I do notice it..."; "...Noticed the points and stars, and saw that it existed, but keen on seeing if I could hit 2000..."
G1	P31	3	"...there should be options to do more routines in a day to add to the number of earned points..."
G2	P05	2,4	"...I did a lot of physical work...my pedometer reading was way over the standard ..."; "... I try to hit my 10K steps daily"

Group	Participant	Week	Sample Participant Responses
G2	P18	5	"...wanted to do more walking to add more steps..."
G2	P21	3	"...now I am doing 10500 steps compared to before (2000) ..."
G2	P23	1,4	"...I need to work on this now to improve my number of steps a based and what you mentioned to me... (about daily step targets) ..."; "...how to get the number (tracking steps) is quite important for me ...how much does it weigh ...how much do I weigh...? have any calories been eaten, burnt...?"
G3	P15	2	"...I just look at my watch for the hours spent, and if I have done my routine ...I stop..."
G3	P25	3	"...I'm not so keen on now on any of the calories but I'm more interested is my weight..."

Table 76: Participant Responses - Focussing on Motivational Affordances

Group	Participant	Week	Sample Participant Responses
G1	P04	1	"...see it (app) helping a person like myself to be mobile and flexible and not for building muscle..."
G1	P08	3	"...yes .my doctor says to do this, so I'm going to do this (app), so a little factor here, the little factor there... my doctor saying something, my knees are saying a couple of things ...and ...but...it is not that there is one thing ...it is a cumulative thing ...you are asking me those questions... it's triggering some new things in my brain..."
G1	P10	2	"...I realize that with age certain things change. But I had a different, mental scale to suggest how many good years do I have left, with optimal health..."; "so, for me, I need to be aware of that activity level; so, this app feels like a first step...and there is validation of effort..."
G1	P11	1,2,3	"... (I) want to live long and prosper, be healthy, active and energetic"; "...this app will help to make be a bit more flexible...and perhaps lead to a mind body optimization..."
G1	P16	4	"...I feel like doing more of this week I wrote there I felt motivated to do more exercises this week of just being more of their because the site made me a bit more aware of the health benefits, ..."

Group	Participant	Week	Sample Participant Responses
G1	P24	3	"...once in a while as you go along if you throw it in (slogans, images) ...so that the user of the app internalizes them and feels have some images, have inspirational imagery with it like, like the eagle, color of course, and inspiration to those things become a goal..."
G1	P29	2,3	"...so, that it's not so stressful and it's not strenuous and yes, it (app routines) is quite valuable. ..."; "...and I understand that as you get older the flexibility part is important and you got to work at it..."
G1	P31	4	"...so, I can see that it's (app) a blessing from that matter because it allows for the training of the muscles from a flexibility perspective ..."
G2	P02	2	"...reminder (presence of pedometer) that exercise is important at my age..."
G2	P05	2,4	"...be fit and maintain independence, and I do a lot of walking..."
G2	P13	5	"...motivation is well-being and staying active for good health especially at this age..."; "...being fit that's the main thing and that's only possible if I'm really active...so I walk and looking at steps help..."
G2	P21	3	to be healthy and add two years to my life..."; "walking a lot for health..."
G2	P23	1, 6	"...keeping active...really the big thing is not to lose the ability to be active ..."; "...or lose the ability to be flexible..."; "...so I monitor my walk..."
G3	P12	2	"...Desire to lead a normal life..."
G3	P25	2	"...so, it's basically living a good life style being healthy and fit..."

Table 77: Participant Responses - For a Healthy Lifestyle

Group	Participant	Week	Sample Participant Responses
G1	P01	1,2	"...ability to do the steps in the correct order, ability to do those components..., and the videos help..."
G1	P04	2,3	"...its home and I have to get away from home, this allows me to do these away from home..."; "...challenges with operating the computer but I can try, but the phone would be easier..."
G1	P10	2	"...just for me how to do this, I need to do this first thing in the morning..."

Group	Participant	Week	Sample Participant Responses
G1	P11	1,2,3	"...I am not good at prioritizing...in terms of importance level do I have so many things on my list and some are incidental, some are inconsequential, some more important than some are you know unimportant..., so having a schedule like his helps..."
G1	P24	1	"...but I do stretching exercises right in the middle of the living room if somebody else is watching TV I just do my stretching right there and other than the gym because at the gym it's kind of dirty the gym so it's easier to do it at home that is clean... I do a lot of floor stretches at home..."
G1	P29	3	"...I'm not really looking to tailor it necessarily myself, I think just having the variety, would help..."
G1	P31	3,4	"...but, I mean for me it (when to do the exercises) is really not important because I would do it..."; "...I would say that it took me about 10 or 15 minutes to do these exercises (daily)..."

Table 78: Participant Responses - Freedom of Usage

Group	Participant	Week	Sample Participant Responses
G1	P01	1,2	"...pushing so that you get the 10th second as opposed to your 8 seconds, you can do this, pushing to do or achieve something more is a big thing from a personal trainer, that wouldn't happen here in this online place..."
G1	P04	2,3	"...I think that you should change the entire routine and stuff so it takes you to a different level and it's much more difficult, not more of the same and levels, and difficulty is more important than the reps and steps... I noticed at but some of these weight-lifters they do about three reps on the giant weights, that's it, and they are well built, so it must be working, ..., this (in app) would be more fun to do..."
G1	P08	3	"...I do enjoy the outdoors, so it would be good to have an exercise without knowing that you are doing one, which is what fun is for me..."
G1	P10	2	"...but I am still working, next week I am free of work and I could get back to more walking. And the weather is fantastic...and I do the app exercise outside..."
G1	P11	1	"...Fun is about meeting my goals each week... and accomplishing what I set out to do..., getting all the checkmarks for the week felt good..."

Group	Participant	Week	Sample Participant Responses
G1	P31	2	"...I like the core exercises because I never thought I could do these giving me a different perspective now..."
G2	P23	2	"...I don't check out on YouTube and look at exercises ... I used to before... I've got used to purchase a CDs and do those exercises... but I find it grindingly boring really boring....and therefore I walk a lot and the fun part is the changing scenery..."
G3	P12	7	"...by going to different locations for doing exercises..."
G3	P27	1	"...now I can do things the way I can, do it by one time, any time at my own pace due to retirement..."; "... that's the fun part of retirement, beauty of the time availability..."

Table 79: Participant Responses - Fun and Recreation

Group	Participant	Week	Sample Participant Responses
G1	P04	2	"...but I was a bit careful and I also feel that that some challenges the last week were good and tougher..."
G1	P08	3	"...these short bursts of training every day is good..."; "...so I'm fact that I'm engaging in this, I can probably do more but when I don't feel well or I'm not mentally or physically not in the mood I'm not sure about that..."
G1	P11	1	"...this (Spirit50) is something that I could do, and include and do any time so that I could just do this also at any time..."
G1	P16	1	"...I think I was on the site for six days, made me aware that I was lacking strength in my arms..."
G1	P24	2	"...intrinsically I am a lazy person I don't want more... I want less... but these are easy dessert of the easy side compared to the end of the right spend in the gym this is nothing so it's like so that's why these are good as a compliment for what I'm doing so that's where I can combine this with what I'm doing in the gym so I can come by and flexibility aerobics and strength..."
G1	P29	2	"...my wife and I want to do this together so that at least we can track us..., I think these exercises are good, it's a good compliment for my regular routines..."

Group	Participant	Week	Sample Participant Responses
G1	P31	2,4,8	"...felt that I could do it..."; "...showed me that I could do wall push ups..."; "...made me aware that I lack upper-body strength...so I have decided to enroll in an upper-body strengthening exercise..."
G2	P23	8	"...totally, absolutely, this process that you're doing here has been a totally a big influence on my change in attitude in helping to add more challenges to add more challenges to the routine....."

Table 80: Participant Responses - Influenced by the App/Artifact

Group	Participant	Week	Sample Participant Responses
G1	P04	2	"...I was told not to do any treadmill but do the elliptical so that it does not hurt my knees which one of them is a replacement...these routines from the website are light and I am keen on doing this"
G1	P08	3	"...my doctor says I should do more exercises, so I want to do more, but, I hate doing boring routines..., the app routines are simple and I do not mind doing these..."
G1	P11	3	"...if I have more instructions by someone who knows what they're doing and I'm motivated ...motivated to do more..."; "the video shows that the trainer is in great shape and I am interested to work more..."; "...my sister-in-law has her Fitbit linked with all her friends and she is younger than I am and she's into groups so you have updates..."
G1	P24	4	"...if I have an injury ...I do something different that required more strength then I had to go back and add something to it based on what the physiotherapist recommends...the ones that we do through the app are easy and light and does not hurt..."
G1	P29	2	"...I did do the personal trainer thing a few years ago, and then recommended certain exercises based on age and my goals..."
G2	P02	4	"...totally inspired by younger students (in gym) around me"

Table 81: Participant Responses - Inspirational Influencers

Group	Participant	Week	Sample Participant Responses
G1	P04	3	"...some of the trees fell down and it's quite expensive to chop it down... like \$1,500 but tree I'm going to use my line of credit to do this and unfortunately it's all stress affect your muscles..."
G1	P08	2	"...I find this is repetitive... if I plan to do exercises, I fail..."; "...so going to the gym is not me ..., and this allows me to do this at home..."

Group	Participant	Week	Sample Participant Responses
G1	P10	4	"...getting too routine... to get to be more challenging and to be honest then I am a bit more engaged..."
G1	P11	3	"...one of the things that I'm not good at is not getting up early and you know by the time you do a bit of stretching and a bit of walking I see that it's late in the day..."
G1	P24	3	"...my gut reaction is, if you told me to change exercises, make it a little more challenging, my gut reaction would be not to do it, would be negative which is bad..., but I prefer the apps routines and when I get bored I want to change it myself..."
G1	P26	2	"...it's frustrating that I didn't get a chance I didn't make the time to do some exercises, got caught up doing something else..."
G2	P02	7	"...was a slow week, too hot outdoors to really enjoy exercises..."

Table 82: Participant Responses - Limitation of Resources

Group	Participant	Week	Sample Participant Responses
G1	P04	1	"...I want to do this ...to feel able to be more active..."
G1	P08	2,5,7	"...part of the reason to have joined this study...to see if I could do an eight-week plan on an app...because...if I set myself up to do something, I fail..."; "...It's also the mental satisfaction of having done it correctly..."
G1	P10	4,7	"...I realize it's on me and nobody else..."; "...but I feel bad that I was not able to get into it more so that I could get the maximum benefit (from the app)"
G1	P11	1	"...I want to optimize the pleasure in my life, from working, from health..."
G1	P24	3	"...intrinsically I am a lazy person I don't want more... I want less... so it's like so that's why these are good as a compliment for what I'm doing so that's where I can combine this with what I'm doing in the gym so I can come by and flexibility aerobics and strength..."
G1	P29	2,7	"...but I am doing more and this helps to compliment..."; "...the site exercises helped me to relax a bit..."
G2	P05	7	"...the motivation was that the place looks amazing and you have to do the landscape to make it look amazing..."

Group	Participant	Week	Sample Participant Responses
G2	P13	7	"...Being inactive other than an occupied mind for most of the day was a sick feeling for me and so had to do exercise..."
G3	P25	1	"...also, build your own self-confidence as well..."
G3	P27	3	"...is not completed the weekly exercise I feel lazy..."

Table 83: Participant Responses - Mental Wellbeing

Group	Participant	Week	Sample Participant Responses
G1	P01	3,7	"...there is a commitment to make me go on a regular basis...and I can do this (app) easily in between..."; "... I added my own routines to make it a bit more challenging..."
G1	P04	2	"...liked it (the exercises on the site) ...did not have a ball or the stretchy band (barriers)...but tried it anyway..."
G1	P08	2	"...I prefer self-monitoring to a certain degree..."; "...able to keep with the program..."
G1	P10	2	"...However, the other exercises and the steps and reps are too easy for me and could become boring....."
G1	P11	1	"...maybe when I was in high school or university I didn't realize then what I realize now study regarding habits and I like being here doing this study about these exercises to improve flexibility, even though I am an active person, that I am not a flexible person, I am inflexible in some areas, so I see the value of these exercises..."
G1	P24	3	"...it's my value system thanks to what I got from my parents.... they didn't want me to sit around the house doing nothing... nothing in the house doing nothing on the holidays... didn't want me to sit around and watch TV and waste time. I make time to do this (app) because it is easy. And does not take time"
G1	P26	4	"... I like to be fairly consistent with what I do doing my exercises regularly is more important...and I include these exercises (app)"
G1	P29	2	"...gym fits into my schedule...and I was able to include the app routines into this schedule"
G1	P31	5	"...that's how I used to exercise when I went to work, I used to go to the gym part of the work thing I will do it (app) first thing in the morning so that it's out of the way..."

Group	Participant	Week	Sample Participant Responses
G2	P05	2	"...what I do currently is a routine..."
G2	P18	2	"...Started a daily boot camp and want to stay with it...."
G3	P25	1,4	"...the same the regular thing, for us..."; "...it's a regimental thing, we have been doing this for over 30 years ..."
G3	P27	3, 5	"...we have a set schedule to do it every morning..."; "...the routine was a good thing but we have been doing it for the past so many years, it has become a habit..."

Table 84: Participant Responses - Routine/Lifestyle

Group	Participant	Week	Sample Participant Responses
G1	P01	2	"...go with a friend and a few others whom I know..."; "...but, don't compare with my friends..."
G1	P10	2	"...If I was always part of a team, I work well towards the team goals....."
G1	P11	3	"...so, you know my motivation, my trigger is much higher in a group than doing it by myself, for me to be better I want to find the trigger so that so that I can be motivated to do this on my own...perhaps this app may help...on an ongoing basis..."
G1	P24	3	"...Let's say that I am on the treadmill.in my living room, I was on it and there was a virtual connection.....if I could some of the people who I see in the gym...virtually...that would be motivating ...because I can speak, say hi to somebody... that will be motivating ...because I am not alone at that time on Sunday evening..."; "...you know...it's not that I don't like them... I welcome conversations... but I feel that I do not have a need for them...but I feel that I need them around..."
G1	P31	5	"...for me to do three hours of transit is worth it because I'm challenged in the hike and I also like it because I'm with the group..."; "...and also the social aspect of being together with a group of people but I'm walking...."
G2	P05	2	"...I like doing a lot with family and friends..."
G2	P18	3	"...I like doing Karate routines alone and with the team, walking I prefer alone so that I can think, but company is also not bad..."

Group	Participant	Week	Sample Participant Responses
G2	P23	4	"...I also go golfing with my husband but he is at a different level than I am..."
G3	P17	3	"...by exercising out door I could meet who are exercising..."
G3	P25	3	"...I am always doing this with my wife for the past 30 years. The routine allows me to reflect on what I want to do in the day ..."
G3	P27	3, 5	"...I like to go out with my friends to do some general walking to have some girl time..."

Table 85: Participant Responses - Social Connections

Group	Participant	Week	Sample Participant Responses
G1	P04	6	"...I thought it was doing more of the deck staining and physical activity followed when doing the deck..."; "...I thought of it this was because of this study..."
G1	P08	3,6	"...so, did not do this because I wanted to do the exercise but I had to deliver something back and forth so in the process I did some exercise, so right there I did it and I didn't even think about it... that's my style....."; "...like I said when I get that urge, I don't mind what I see here, and I'll do it..."; "...but now I'm starting to think about it, I don't say ...hey...let's go and exercise, it's a by-product for me..."
G2	P23	4	"...and I'm not thinking about how many do I have to go through or how many reps or steps I got to go through, or how many of these should do after going through, I'm just watching the news and doing this....."

Table 86: Participant Responses - Spontaneous and Subconscious Activity

Group	Participant	Week	Sample Participant Responses
G1	P04	2,3	"...I have scoliosis and it has affected my posture so it is a challenge (barrier) ..."; "...I was told not to do any treadmill but do the elliptical so that it does not hurt my knees which one of them is a replacement..."
G1	P08	3,6	"...so, did not do this because I wanted to do the exercise but I had to deliver something back and forth so in the process I did some exercise, so right there I did it and I didn't even think about it... that's my style....."; "...like I said when I get that urge, I don't mind what I see here, and I'll do it..."; "...but now I'm starting to think about it, I don't say ...hey...let's go and exercise, it's a by-product for me..."

Group	Participant	Week	Sample Participant Responses
G1	P10	2	"...I tried to sit down on the floor and felt quite stiff, and immobile..., so this app may help me..."
G1	P16	4	"...my strength things is weak, my back is bad, but I'm trying to get it back, so those types of things..."
G2	P18	2	"...so, I was training and exercising 25 hours per week and I tore a muscle in my hip and my pubic bone and then I kind of...dropped off..."
G2	P23	4	"...well...for one age is one... I need to improve my flexibility I have scoliosis and I just found out a couple of years ago, so again it goes back to keeping myself flexible....."
G3	P12	6	"...obesity...Doctor's advice to keep the body weight under control..."
G3	P15	3	"... I have had a bypass surgery, and need to daily one hour of recommended exercise..."
G3	P17	3	"... is to keep my diabetics under control, so more exercises..."

Table 87: Participant Responses - Treatment for Health Issues

13.8.2 Setting up Goals

Group	Participant	Week	Sample Participant Responses
G1	P04	6	"...I prefer to combine gym, flexibility (app) and household activity..."
G1	P08	3,6	"...focussed on household activities leading to exercises..."
G1	P16	4	"...work with combining low intensity with high intensity..."
G2	P21	2.3	"...Yesterday I was in the gym, one of stretching and strength, cardio and stretching, 45 minutes to 1 hour..."; "...decided to walk a lot due to the pedometer to see how far I could per day..."
G2	P23	5	"...because as we talk more about what can I do to challenge myself ... if you think walking or hiking is a Humane sort of activity then an elliptical machine... elliptical machine is more time and tougher... and toughen the tension in the legs..."
G3	P15	4	"...I must walk at a brisk pace for at least one hour so that I can feel the burn..."
G3	P25	3	"...yesterday I played golf, today to get to take it easy, tomorrow we doing the 12 and a half kilometers..."

Group	Participant	Week	Sample Participant Responses
G3	P27	4	"... I do not have a fixed plan...it is just that I must walk and jog based on my routine which has become a habit..."

Table 88: Participant Responses - Combining Exercise Types

Group	Participant	Week	Sample Participant Responses
G1	P11	3	"...this motivation thing, I play hockey 4 times a week, I don't exercise that regularly, but I'm religiously going to those, I kill heaven and earth to get there... but if I had something that said that if do these Fitness things on my own, like this app, (you could do your hockey better) ..."
G1	P31	2	"...even if I'm home early and have to get up Friday morning early, do the app, then do my two hour walk just to offset all of the sitting..., I am enjoying it"
G1	P29	8	"...one of the things that I was thinking, was that, earlier, you know how it is regimented (app), like I have to do it on Sunday Tuesday Thursday and at first I did not like that, but, now I see the value in that, because if you extend it over time, otherwise I could cheat and do it over 3 days, and I could skip, a whole week and do it for three more days..."; "...but I did not because it was an interesting combination"

Table 89: Participant Responses - Enjoying Combination of Activities

Group	Participant	Week	Sample Participant Responses
G1	P10	2	"...and you have to start and stop to a routine, at home when I exercise, I walk around and there is no organised structure, the structure helps (app)..."; "...know at what level you are comfortable at ...and these are the options we have for the next 5 or 8 weeks, check which one you want, low maintenance, medium challenge, or a kamikaze style..."
G1	P11	6	"...because of the site (spirit50) stretching I have also been a bit too conscious of my posture while walking so I tend to throwback, my shoulders..."
G1	P16	1	"...I notice and it (app) has helped me realise how little strength I have in my arms ... and that's what I noticed, when I played tennis the last couple of times that I did not have that kind of strength (which I used to have) ...and I need to build that up ..."
G1	P25	3	"...because of shorter challenges you would also love to try some..."

Group	Participant	Week	Sample Participant Responses
G2	P23	2	"...I would like to do a minimum of 10,000 steps that's a minimum I mean I know when we started out I said it was 500 steps a lot and that strange now that I feel that I want to do more and more..."
G2	P13	4	"...I also am motivated to improve my posture, reduce lower back pain and being fit..."
G2	P18	2	"...weight loss is easy to measure..."
G3	P12	5	"...with my (excess) weight loss due to regular exercise..."

Table 90: Participant Responses - Focussing on Specific Goals

Group	Participant	Week	Sample Participant Responses
G1	P08	2	"...I make lists, I'm a list person, I have a list and I have great pleasure in scratching things off the list...; so the checking off exercises is similar...feels good to check it off"
G1	P10	3	"...and then see if I could do that If you do 8 reps of a certain step when that gets easy, you up it a notch...and you can measure that... .."
G1	P11	4	"...My reach is improving...because of this (app)...in touching my toes...so I am increasing it up a notch..."
G1	P31	2,5	"...I feel that these exercises because I can't really feel like the new exercises (added) I can feel that it is stretching my legs and I'm thinking ...Oh!! yeah!! ...these really do work..."; "...and I am at 1200 points and a few stars...I hope I can get to 2000 points before 8 weeks..."
G2	P23	4	"...it makes a big difference for me because I know th t there's a big brother (pedometer) watching and I got to do more work...and I feel happy that there is some sore of measure or reinforcement of the efforts ..."
G3	P25	2	"...I don't think I need one (badge) because it all depends on what you want to achieve in life right if you if you want to go to a point to where you want to train for yourself something that you're looking forward...d to then that's another thing but for us, it's just about keeping ourselves fit"

Table 91: Participant Responses - Focussing on Motivational Affordances

Group	Participant	Week	Sample Participant Responses
G1	P04	2	"I want to be mobile...but I'll try to make it a point to visit again (app) when things cool down, because, it is making me aware and I can do it anywhere once I remember to do it..."
G1	P10	2	"Not specific as such, just want to be active and mobile, ..."
G1	P11	4	"...at my age if I don't start working diligently on my health you know... what you put in is what you get out... there is so many things that interest me.....including doing this app"
G1	P24	5	"...as a gymnast, you are too old for gymnastics by the time you reach twenty...."
G2	P13	2	"...Mostly it is the feeling of well-being that motivates me..."
G2	P23	2	"...I can't run anymore, because I've got osteoporosis, and arthritis so lot of sports that I used to do is off-limits now... out of my ability now I just love to walk now and I feel confident that it competent at it..."
G3	P25	2	"...like you always say as you grow older you try to cut down on the portion and so that's one of the motivation factors dinner also to make sure make sure that my pension of outlives me..."
G3	P27	3	"...just said any goals for myself I do it because I know that I'm doing something good to my body so whatever good it is I know it's good how good it is I don't like that or how bad it is if I'm going to let you know I have done how much do since (G)..."

Table 92: Participant Responses - Improving Health Outlook

Group	Participant	Week	Sample Participant Responses
G1	P04	1	"I was able to up to 90lbs, we started off at 60 and kept going. As I kept getting better in shape...I also did push with the app routines"
G1	P10	2	"I have set a goal to use the stairs instead of the elevator, just to get into the mode of working out...and the app showed me that I could do more than what was prescribed..."; "...I always have the option of doing a couple more, I feel it too less intense (each week), but today, I found the Bird-Dog to be a bit strenuous as it was good so it helps with the core..."

Group	Participant	Week	Sample Participant Responses
G1	P16	2,3	"...I have been planning to start running to build up some stamina and play some tennis, but the app showed that I need more arm strength... it would be good to have the option to increase the intensity of the work out or choose a difficult version"; "...to have different intensities so that you feel that effort is required, and is not easy..."
G1	P29	1	"...do small steps to improve my flexibility improve my endurance and the overall level of fitness as opposed to losing weight or building muscle..."
G1	P31	6	"...I think...I feel like I would get a lot from this kind of a program, like the stretching the band (exercises) and the muscle toning I feel like it is so hard to do, but I can do it, but it will help to improve my upper body strength..."
G2	P13	2	"...I try to add more distance to walking each day..."
G2	P18	4	"...increase the workout sessions..."
G2	P23	1	"...I also don't mind changing it up a bit of if there were a few exercises to be done when I'm walking just to change it up and bit of deviation..."; "...I plan to continue to do the hills and valleys on my trail to hit more than 10,000 steps per day..."
G3	P12	2	"...add more walking and measure things such as heart rate and weight loss..."
G3	P17	3	"...work towards increasing the walk time..."

Table 93: Participant Responses - Increasing Challenges Progressively

Group	Participant	Week	Sample Participant Responses
G1	P04	2	"...with this I am able to do this from home, but I have to find a computer, a mobile version may be good"; "...but it acts like a virtual trainer, so it has its advantages because it also good to feel that there is a coach..."
G1	P10	2,3	"I set up a routine and I get to it..."; "...I do like planning your own exercise routine..."; "...When I do the exercises on my own, I have the flexibility to go for it when I want it, start when I want and do what I want. There is that combination..."
G1	P11	2	"...We could see the progression based on these exercises because I really want to improve my flexibility..."

Group	Participant	Week	Sample Participant Responses
G1	P16	2	"...So, when your prompt comes out on each day you're like going to the gym..."
G1	P29	3	"...I needed to have some routine or it's pretty easy to get out of shape if you don't have some sort of a routine, other than golf, so the app helps..."
G1	P31	6	"...so, I guess also the fact that once I do it once to the day I don't even have to log into the app again..."; "...If I could do it twice a day because it is so short and fast... that's kind of the more that I could do... It doesn't go on for long for a long time I could do this more than once..."
G2	P02	2	"...no, I am just fine in doing what I am doing..."; "...and I am good in motivating myself to do more..."
G2	P18	4,5	"...I am self-motivated..."; "...No, I started counting calories but found it too much trouble, I eat sensible and am cutting out junk food..."
G2	P23	1	"...I also don't mind changing it up a bit of if there were a few exercises to be done when I'm walking just to change it up and bit of deviation..."; "...I plan to continue to do the hills and valleys on my trail to hit more than 10,000 steps per day..."
G3	P12	6	"I try to go to different locations of exercising ..."
G3	P15	2	"...Be fit and healthy, personal routines; planning; watching routines; perfecting; consistent monitoring of diet..."
G3	P25	2	"...I also do internet search on YouTube and also about eating the way to eat try to make sure that we don't eat a lot of fried food and things of that nature..."

Table 94: Participant Responses - Self-Regulating Routines

Group	Participant	Week	Sample Participant Responses
G1	P01	2	"...I like taking part in group exercises are more fun because of more people aiming towards a common goal..."
G1	P11	4	"...A group excitement is good...if you meet with people ...When you meet people who are inspiring...you don't mind doing a bit more, putting an little extra effort in doing something...and I like coming out and doing something more ...which is going to be a bit more positive than a different vibe with the general population..."

Group	Participant	Week	Sample Participant Responses
G1	P26	2	"...Also, so I don't run into the same people every time I've been there, and it is immaterial if I do so..."
G2	P29	6	"...having someone to share in doing physical activity is a great motivator...work out partner"

Table 95: Participant responses - Social Interaction

Group	Participant	Week	Sample Participant Responses
G1	P08	1	"...tracking back for me is a punishment, if I go and do it, I'm happy that I've gone and done it, because I have this urge to go do it then I go for full force and for those 3 hours I'm just going up and down and doing all the work and activity and physical activity, and cleaning g the house cleaning the yard doing exercises ..."; "...My goal is to do work, if it leads to exercises and physical activity then it is a by-product of my work activity which is then a great and satisfying workout..."
G1	P16	3	"...doing exercises or going to the gym is a ...forced thing...but if you are doing an activity that you enjoy...say like riding a bike which leads for workout then it is really refreshing..."
G1	P26	2	"...Also, so I don't run into the same people every time I've been there, and it is immaterial if I do so..."
G1	P29	6	"...having someone to share in doing physical activity is a great motivator...work out partner"

Table 96: Participant Responses - Subconscious and Spontaneous Activity

13.8.3 Feeling of Accomplishment in PA

Group	Participant	Week	Sample Participant Responses
G1	P08	3	"...the point is that I really want to increase the frequency of that spontaneity and all that reward (app) and do more of that so that there is a feeling of doing something and satisfaction.
G1	P10	5	"...the morning or twice I'm also doing this every day of the week did the gardening mow the lawn..."
G1	P11	3	"...the walking exercise (app) indicated 15 minutes' walk at a moderate pace. This was easy for me, I did more than an hour ...but then I was interested in the other exercises..."

Group	Participant	Week	Sample Participant Responses
G1	P16	2	"...it's a bit of a trigger in my head that I can do this once a week...";
G1	P24	2	"...this is my fourth session (good) and I got 4 more to go (app)... I did a few online activities of online sessions...my mind is all over the place...in a million other things....."
G1	P29	6	"...I might do it (app) one day and I then I went for a bike ride... I wouldn't do the same thing every day...so a variety is good, gets away from being boring..."
G2	P23	3	"...not really, no, I'm planning them (trekking trail) out as I'm going, I'm seeking them out actually..."; "...I'm just not sure I could be possible I'm just trying to see what else I could see or do something else, since I started on this..."
G2	P13	3	"...was able to do the least 3 times a week of 40-minute exercise..."
G2	P18	2	"...I did and extra 1/2 an hour on the stair stepper..."
G2	P21	8	"...Did a lot more of walking review per week of steps
G3	P15	4	"...kept myself quite busy by doing all sorts of things..."
G3	P25	2	"...so, some of her friends of suggested why don't we do a half marathon..."
G3	P20	1	"...did more walking..."

Table 97: Participant Responses - Adding new Challenges

Group	Participant	Week	Sample Participant Responses
G1	P04	3	"...it made me conscious of my posture and that I could try to improve"
G1	P08	5,6	"...hey...this week I was doing some walking and I got to the top of level 5 (floor) and I realized that I wasn't that winded when did get to the top, and I was doing a good little click (fast stride) , hey I had the sense of a good moment and I thought of you, this Spirit50 that we were doing..."; "...but then I remembered doing the stretches here in the site (Spirit50) I did notice a difference it was it harder before...now it felt easier..."
G1	P16	2	"... it (app) made me feel that my arms were weak, and I had to work on improving my strength..."

Group	Participant	Week	Sample Participant Responses
G1	P11	6	"...I just come here and do some exercise and the same stretches over the week and it's helped and it has put something in my brain in some of the strange pockets (of the brain) that that it's good it's a good feeling, it's a good thing and the value is good..."
G1	P31	3	"...I realised (from doing the app exercises) that I had low upper body strength, and not I feel I must do something about it ..."

Table 98: Participant responses - Influencing Activity through the App

Group	Participant	Week	Sample Participant Responses
G1	P04	4	"...I thought today was a bit of stress and was more difficult (app) it was a sudden jump in the intensity but I feel good that I was able to do it, I haven't done the plank so it was difficult to get the balance..."
G1	P08	5,6	"...hey... wow I have done 3 weeks...I don't know if this is an accomplishment or reward... and I cleaned up the yard and made it look better..."
G1	P10	4	"...starting to challenge me (app) and starting to be a bit more rigorous ... it's interesting to me now I can see the point's, displayed over a period of time..."
G2	P03	4	"...completed lots of steps..."
G2	P05	2	"...Completed gardening, doing physical activities and doing the pedometer target, 10000 steps per day..."
G2	P21	6	"...Did a lot of walking review per week of steps...I do not normally walk a lot..."
G2	P30	3	"...same as completion of a lot of walking..."
G3	P15	3	"...carried out some repair work with a new special tool..."
G3	P19	2	"...walking, gardening, running, climbing steps..."
G3	P25	2	"...being able to complete the 12.5K run over the last week within a reasonable time..."

Table 99: Participant Responses - Completing Difficult Challenges

Group	Participant	Week	Sample Participant Responses
G1	P04	4	"...I couldn't go down to the gym but I think the app movement was good because I felt that I was able to do it so it's a nice feeling..."
G1	P08	3	"...what I need to do is increase those moments of satisfaction (doing app), and I like to go outside I'm trying to be cognizant of the fact that the weather is better..."
G1	P11	3	"...taking a breath in and trying to move forward from the theme (app) from the back exercises to the arms, I tried as hard as I can and then you think you can do challenging exercises...."
G1	P26	8	"...I feel it more important for me to do these things (app + outdoors) ... when I'm away from exercise the negative impacts are greater than when I do the physical activity and that makes me feel good... maybe subconscious I guess..."
G2	P02	3	"...carrying on with the exercise routine and feeling better..."
G2	P13	5	"...felt energetic after doing all the walking..."
G2	P23	2	"...but I think getting to engage with you and this. I've always wanted to do this...feeling content.... as sort of initiated doing the step thing... with the pedometer ..."
G3	P07	3	"...happiness that I did it, I would be sad if I did not do this..."; "...felt very good after walk..."
G3	P09	2	"...I am more energetic and more enthusiastic ..."
G3	P25	2	"...great feeling of achievement on completing the ½ marathon ..."

Table 100: Participant Responses - Feeling of Mental Satisfaction

Group	Participant	Week	Sample Participant Responses
G1	P04	2	"...I did a good workout and felt my muscles cry...also I also had a couple of people who were new and they commented, boy you really do a workout...I did, ..."
G1	P08	3	"...I thought my arms were dying..."
G1	P11	3	"...I think that these exercises have been there picked out rather well so that's a good combo of fun things to do and I tried to you know make each one do a little bit of a burn in terms of my muscles..."

Group	Participant	Week	Sample Participant Responses
G2	P12	3	"...I believe that I had the feeling of having burned enough fat this week...."

Table 101: Participant Responses - Feeling the Burn

Group	Participant	Week	Sample Participant Responses
G1	P08	6	"...I wasn't complaining that it was a lot of work it was hard it was hot outside but as far as the drudgery and the pain Factor...the fact that I am in week six is a big thing for me..."
G1	P10	3	"...the first 10-15 minutes is when the body is trying to push and mentally you are wavering, so I feel like doing more than 15 minutes so that is the threshold for me to complete...even when I go to the gym, I tend to work out and track myself, and that is a challenge, to work out and track myself...."
G1	P24	3	"...walking helps to improve blood circulation and also helps to have a different perception and the progress indicated shows me that I am going through the program...."

Table 102: Participant responses - Feeling Validated for Efforts

Group	Participant	Week	Sample Participant Responses
G1	P08	6	"...Once we got over that (timer issue) it was easy and more coordinated and felt more agile...and I do not feel out of breath as before. ..."
G1	P10	3	"...my measure of accomplishment is weight, and maintaining weight..., so I work-out and the app gives me the flexibility exercises, helping with my body..."; "...With these ones, the goals seem to be different to improve flexibility, I do feel towards the end that the muscles get tighter. The cardio is light stuff... so it is not that intense..."
G1	P24	3	"...my stretching isn't improving, it isn't... it isn't improving or getting worse, so much, better thank God it is not deteriorating..."
G1	P31	3	"...I like the fact that it was different... and I like that I learn something new like doing push-ups against the wall which was nice and refreshing..."

Group	Participant	Week	Sample Participant Responses
G2	P18	2	"...so, the moment my work done I just disappeared from here and when I do my thing, exercising and walking and doing it during my training which is helping you bring my weight down..."
G2	P23	2	"...it's not all in terms of quantifying but it's more or less like feeling better...when I am able to keep my weight down doing that, end up feeling more you know more muscles tiredness, that sort of thing from a health perspective that's more or less what I felt about accomplishment..."
G3	P14	4	".. good physique and peace of mind..."
G3	P17	5	"...I feel that I have good stamina physical and mental relaxed..."
G3	P20	4	"...I feel I have more stamina than the previous week..."

Table 103: Participant Responses – Improving Body Conditioning

Group	Participant	Week	Sample Participant Responses
G1	P16	3	"...I felt that because the numbers were increasing (progression meter), the intensity was increasing, which was good to have a slow climb..."
G1	P31	3	"...and I'm able to do push-ups, I'm able, I am confident to do it, at first I was wondering whether I was doing it right, but after you watch the video couple of times to refresh yourself.... so, the videos are good..."
G2	P18	2	"...I could do it ...and it was a sense of achievement..."
G2	P23	2	"...these activities that I'm doing right now it's something that I can sustain or happen to sustain for some time..."; "...I am pushing myself to do more. I am getting much more of a sense of what I can accomplish during the walk..."
G3	P12	5	"...I was able to do the usual weekly exercise targets.... completed on time...."
G3	P17	5	"...I feel I am physically very fit for my age..."

Table 104: Participant Responses - Improving Confidence

Group	Participant	Week	Sample Participant Responses
G1	P04	2	"...I also now do understand what is happening to me (app)...with the broken vertebrae, causes the spine to curve like that so, therefore, the rhomboids muscles which go down from here they go right down here and then they're always under stress should really get to a sore back so if I straighten up that then they're not as stressed....."
G1	P24	2	"...accomplishments as I wrote in in my document the last week I had very less carbohydrates, because, I love bread so that's itself is an accomplishment for my part....."
G1	P31	2	"... sometimes when I overdo it in the garden and then I have a sore back and I mean but stiff... but when I exercise (app exercises) another time I seem OK..."
G3	P07	3	"...I was able to do the usual weekly exercise targets.... completed on time...."
G3	P17	3	"...I could control my sugar level without medication..."

Table 105: Participant Responses - Improving Health Condition

Group	Participant	Week	Sample Participant Responses
G1	P01	2	"...if you were lifting 5 lbs weight ...and if next week you came you did an 8 lbs weight, and you would see that there was Progress or Improvement or you would see that there's a physical change or you managed to go up in weights or so..."; "so if this was on the phone I could do this before the Zumba..."
G1	P04	2	"...just by the amount of weight that I could do each week, I could feel that I have accomplished something..."; "...I did the flex exercises from the site and it felt like stretching my muscles..."
G1	P24	2	"...I would imagine that it (in Spirit50) will increase and intensity as the weeks go by and the number of steps and Reps may increase as we progress along so even though it's the first week I don't mind continuing because I'd like to see where it goes..."
G1	P31	2	"...I felt that I wanted to get on some sort of like a regiment of getting like an upper-body exercise which is also good thing about this..."
G3	P15	3	"...was able to do my task very well..."
G3	P20	3	"...felt able to complete tasks..."

Table 106: Participant Responses - Improving Ability

Group	Participant	Week	Sample Participant Responses
G1	P08	4	"...I can see myself progress and keep up with the program and it's done I'm going to do things like stretching against the wall I could be prone to doing that..."
G1	P26	2	"...I was able to get 1000 points on the site, not a big deal, this reassures your effort..."
G1	P29	1	"...as I said if I did exercise the number of times for the amount of times that I have done it then I feel led to success..."
G1	P31	2	"...I want to see if I could do more exercises to get to 2000 points faster..."
G2	P03	2	"...steps...I am doing a lot of steps on the pedometer..."
G2	P13	4	"...steps increased from last week..."
G2	P23	2	"...I'm heading up to...15000 steps (daily, pedometer) and getting up there it all started out then you told me that 500 was too less..."

Table 107: Participant Responses - Inspiring Motivational Affordances

Group	Participant	Week	Sample Participant Responses
G1	P08	2	"...getting the load, it's also a lot of the strengthening of certain areas of the muscles of the body so it's interesting to look at it from that aspect..."
G1	P26	4	"...just completed my routines, and saw that I have more points, and did more stretching because I see the value in doing this prior to playing hockey..."
G1	P31	7	"...exercises are still light or medium intensity, I think I can handle more, and I can ready to up it a bit, ..."
G2	P02	7	"...just carrying on with the walking and exercise routines..."
G2	P06	4	"...finished steps for the week, lots of steps this week..."
G3	P20	6	"...felt able to complete tasks..."
G3	P25	3	"...completed the clean-up of the interlocking in the back, side, and front..."

Table 108: Participant responses - Progressing through Activities

Group	Participant	Week	Sample Participant Responses
G1	P10	5	"...but if I do it with someone or somebody, it keeps me honest and on it, if I'm by myself at home I'll just go to the gym, at home if I'm with somebody, I'll have to have someone to be with me to do that...so, we will see how that works..."
G1	P31	4	"...I need to be careful on how I use my time. I guess it's into also understood that the driver is also to meet the people with whom I'm walking so it's a good thing the social meeting...."
G2	P18	3	"...a friend of mine in Houston posted a work out he did and I copied the program. He told me how hard it was, I found it fairly easy..."
G3	P25	3	"...managed to play with people much younger than me and i still out ran them good feeling :)..."

Table 109: Participant Responses - Social Interaction

13.8.4 Rewards and PA

Group	Participant	Week	Sample Participant Responses
G1	P10	8	"...achieving all the stretching and tracking of body movements was inspirational, the points serve as an incentive because it indicates value for effort..."
G1	P24	8	"...no just the satisfaction of completing this eight-week program...and I'm feeling a sense of being more conscious about doing more..."
G1	P31	8	"...I climbed over the 2,000 points mark, and I was so glad that I was able to do it before the program ended, so I was at 2180 points, helped me to get over the 2000 marker has a goal..."
G2	P23	3	"...the feeling that you have done this and also measuring the X number of hours how much time did I put in it doesn't matter what I feel good of having done and completed the task was a good feeling..."
G2	P30	4	"...beer...felt happy on completion, wanted to review steps per day..."
G3	P25	3	"...was not so much about the awards but the happiness of getting it done and see it done, so there is a feeling that's good..."

Table 110: Participant Responses - Rewards and PA

Group	Participant	Week	Sample Participant Responses
G1	P16	2	"...I do not reward myself with a physical object, but the feeling good aspect is kind of like a reward..."
G1	P26	2	"...I don't necessarily have a high need for outside gratification, it was nice to see the checkmark that you had completed it ...that there is a completion aspect of each of these exercises and if it's good that you're given points but points do not matter to me because I'm more interested in finishing the task..."
G1	P29	8	"...I don't know if the bars and the points mean something to me... in general exercises to me means a lot of satisfaction that I've done it, to have completed the exercise as per shown and I am able to do it so the satisfaction after you're done the exercises pretty good and then you have much more energy..."
G2	P13	7	"...felt more energetic..."
G3	P15	3	"...I like people complimenting me on my work so that helps me to feel happy and... and feel good... and that gives me satisfaction even if I don't get it... I still feel that I've done the right thing and whatever have done is good for the other person, and feels good..."
G3	P17	2	"...I feel always fit and vibrant..."

Table 111: Participant Responses - Having Intangible Rewards

Group	Participant	Week	Sample Participant Responses
G1	P04	4	"...I can eat something now... the cookies...but then you start thinking about calories and then you look at the cookie box ..."
G1	P08	2	"...the second one (reward) would be if I can lose some weight...it would be good too... it's looking better and stand back and look at it and it feels great and that's my reward..."
G1	P10	5	"...I can see that the points are increasing, I think it is important to spend some time rewarding yourself..."
G1	P24	3	"...I want to be fit and I want to fit inside the same position of my belt that's my motivation I hate myself then that gets by when I have to change it my belt position...it's the one that I see as a reward"
G2	P18	2	"...I love exercising but I also love chocolate, I love sweets, and that's why I exercise so that I can have them...and I like beer...so Friday and Saturday I am exercising and having fun....."

Group	Participant	Week	Sample Participant Responses
G2	P23	1	"...and from a feedback perspective and getting obsessed with my weight...and a numbers perspective it's just as if my weight is down and the number is good I feel that's good and that's a good reward..."
G3	P12	2	"...could have an ice cream after the exercise..."
G3	P27	1	"...I wouldn't go overboard and give myself an ice cream but you satisfied I feel good and if I had an extra helping of something that's fine but no I'm quite strict with my diet..."

Table 112: Participant Responses - Having Tangible Rewards

Group	Participant	Week	Sample Participant Responses
G1	P24	8	"...felt happy and the satisfaction of completing this eight weeks as a program....."; "...the 8 weeks that we spent together made me conscious of a lot of things, I mean, the need for feedback, like as we just discussed, as for the value...very satisfying..."
G1	P26	8	"...the positive impact for me of doing the exercises is this is good...but, I don't bring it to mind. Often (as a reward) the feeling of energy and completion is good..."
G1	P31	3	"...I tend to look at the points after I do the exercise so it feels good..."
G2	P13	2	"...I felt energetic and active when I was doing it in after I was doing it..."
G2	P18	1	"...just hard work makes me feel good..."
G3	P19	6	"...felt happy to complete daily routines, added more steps, felt relaxed after..."
G3	P27	1	"...there were no specific rewards just a good feeling that I had a good week..."

Table 113: Participant Responses - Feeling of Mental Satisfaction

Group	Participant	Week	Sample Participant Responses
G1	P16	2	"...yes, there is a kind of self-awareness, based on what we did today, I know that my strength has decreased, I know this is a tangible way of improving my fitness and maybe this is one way to motivate me to address my fitness and health..."

Group	Participant	Week	Sample Participant Responses
G1	P31	8	"...it did help me to understand that I do lack a few things and it also showed me certain things and I was not able to do... that I was so impressed with that, by being able to do this push ups against the wall ...these wall push-ups and I was bragging to my friends that I was able to do this..."
G2	P13	3	"...Rewards for me is feeling of discipline rather than laziness. I am not forced to do any activity, but I know it is good for me and doing it gives me a sense of achievement...."

Table 114: Participant Responses - Having Self-awareness

Group	Participant	Week	Sample Participant Responses
G1	P08	4	"...I realized...yes it (climbing stairs) was great... you know my legs were burning a little bit... but I didn't mind it... you know and I tried a bit harder now to reach and climb the stairs...struggled a little bit more ... just to get to complete the stairs...the thing is I am not into going to do or overcome by Leaps and Bounds.... I'm doing that small incremental rewards...like (P08) happy doing this ...(P08) is happy doing that... the first challenge was to agree to even come here to start doing this Spirit50...and it has helped"
G2	P23	4	"...so, the reward is essentially achieving something or getting it done now ...getting the walking done is just kind of like an accomplishment is serving as a reward..."

Table 115: Participant Responses - Having Sense of Accomplishment

Group	Participant	Week	Sample Participant Responses
G1	P04	4	"...trying to get your back and straight is itself a reward but don't overdo it and so I've been trying to do some of these exercises along with some of the ones that today on this site..."
G2	P23	2	"...I have control over my weight and my sugar level..."

Table 116: Participant Responses - Improving Health Condition

Group	Participant	Week	Sample Participant Responses
G1	P04	2	"...if you do those these also go higher in terms of points score..."

Group	Participant	Week	Sample Participant Responses
G1	P08	2	"...I see that the scratching off of the list (checkmark) makes me feel happy, I got three left while I get there..."
G1	P10	2,5	"...I just got into it and felt like doing it and going for it. But I did notice that it (points) was there...and may notice it the next time. When you start noticing them, then you start to compare them, ... and so on....."; "...the progression also is good to other information so I'm happy to see that I'm in the week of five of the program..."
G1	P24	2	"...they (points) mean something I guess is that the reward as a reward you mean of course when you accumulate points it is a reward because it's something to be proud of and it's memorable so for sure you can hypothetically even show it off to your friends at that you've accomplished this much points this week that itself is a reward..."
G1	P31	5	"...I noticed that my points are going up, which I'd like to see, but, I haven't really found anything really challenging but I can see that my points are increasing and I think ...OH... I am doing more..."; "...I'm interested in knowing how many am I accumulating every day and it's more of an opportunity to do more to gain more points..."
G2	P23	2	"...it would be nice to receive some badges highlighting how many steps of this climb was done, its current like positive reinforcement..."
G3	P20	6	"...completion of activities..."

Table 117: Participant Responses - Inspiring Motivational Affordances

Group	Participant	Week	Sample Participant Responses
G1	P04	2	"...that's what is good about this (app) is that it makes you even think of this site...like on the rowing machine... it was pretty intensive exercise 25 Calories...that's good ...but... I did a lot of work to burn 25 calories ..."
G1	P10	2	"...and when I got the heart monitor, I started recording my heart rate...and you notice that the more you do it for the same level of calories your heart is not pumping quite so vigorously...When you are doing the exercise that machine is telling me that I am burning these many calories and that is my motivation and reward....."
G1	P31	6	"...I believe what I am about to hit the 2,000 points, and that's what I'm excited about.....kind of encourage you not to do anything/something..."

Group	Participant	Week	Sample Participant Responses
G1	P02	5	"...I did 94,900 steps for the week, and an average of 13,557 steps per day..."
G3	P15	5	"...looking at the time and noting that I did the regular 2 hours of brisk walking...that itself is a reward..."

Table 118: Participant Responses - Seeing Results of Efforts

Group	Participant	Week	Sample Participant Responses
G1	P04	2	"...that's what is good about this (app) is that it makes you even think of this site...like on the rowing machine... it was pretty intensive exercise 25 Calories...that's good ...but... I did a lot of work to burn 25 calories ..."
G1	P10	2	"...well if it is ...well there will be more engagement if there were group activities...although I am a loner in the gym. But for something that involves software like this app, this would be a good feature..."
G1	P31	6	"...I think I would enjoy doing that (Pokémon) with my grandchildren...they (grandchildren) don't really enjoy walking that much...my grandson, I took him hiking but wouldn't get very far because the only wanted to do was climb the trees... which that is fun and fine... for him....."

Table 119: Participant Responses - Social Activity

13.8.5 Tracking of PA

Group	Participant	Week	Sample Participant Responses
G1	P04	2	"...today... I just count, in my mind..., but I like the automatic counting or tracking...when I was in good shape last summer I was going twice a week, sometimes 3 times, and I was up to doing 15 reps on everything... 3 times, now I am only doing 15 reps ...2 times ...and I keep a track of that..."
G1	P24	6	"...perhaps I should start checking or measuring my waist every time every week so that I can feel the change perhaps..."
G1	P31	6	"...I like to see the website so number of number of points; the progression and where am I at with respect to the overall goal, and also I was interested in the percentage...how much more do I have to go to finish..."

Group	Participant	Week	Sample Participant Responses
G2	P23	2, 4	"...tracking is actually making me do more work because it's making me more aware ...it makes a big difference it's a, it's a positive reinforcement... I'm now also started using this when I'm doing my yoga so that I can get everything tracked..."; "...and maybe a form checker. Then you are getting reinforcement...instant reinforcement of what you are doing and how you are doing it..."
G3	P27	2	"...I'll check it (weight and posture) everyday morning and evening..."

Table 120: Participant Responses - Improving Body form

Group	Participant	Week	Sample Participant Responses
G1	P04	2	"...I like the reps and steps and the checkmark when I complete the routines on the app...tells me that I have done something ...not to see how it can tell me if it was done correctly..."
G1	P10	6	"...by and large, if it is plotted on a graph I can see this and see if I have improved or not..."; "...if you doing more reps and steps at a certain level, that would be burning ore calories, for me more important that the points was to see how much calories I was burning ... and the points could add to be fuel points which can be used elsewhere for redeeming, you have a Fitbit you could have a combination of weight and calories..."
G1	P26	4	"...I wouldn't change anything but I do like to the tracking it's kind of like an informal tracking but I do but it would be good to see some calories and some progression..."
G1	P29	4	"...I can see that the progression shows it to be 59%, there is weekly feedback, daily feedback, and individual achievements, which are good..."
G1	P31	3	"...I want to see if I can get to 2000 points...and how can I do more to get more points...I should be allowed to do that"
G2	P23	2	"...well that's great, eh not too bad (when I started at 500 steps and thought it was too much) ..."
G2	P18	2	"...I wanted to do more than the previous day..."

Table 121: Participant Responses - Indicating Motivational Affordances

13.9 Phase 4: Themes, Open codes and Properties for Eight-week Study

13.9.1 Motivation for PA

13.9.1.1 Group 1

Theme	Open code	Properties and associated concepts
Accomplishing a goal	Accomplishing challenges with ease; realizing a big improvement; desiring to do something; multitasking to meet challenges; inspiring situations; comparing results; exciting and feeling energetic; keeping commitments; persevering to put effort; understanding the benefits of PA; training for immediate goals	Not gasping for breath; high or low, anything; success, chores, ambitious goals; attitude change, curiosity, hitting targets, ambition, success, simplicity; doing all routines, doing few sessions, new routines, old routines, intensity types, preparing for an activity;
Aging well	Accepting of increasing age; crossing an age milestone; preventing old age; overcoming challenges with aging	Being conscious; getting older; feel good; better fitness
Challenged by activity	Challenging goals for higher intensities; desiring to complete PA; overcoming boring gym routines; desiring to do PA despite hectic activities; persevering on a routine; desiring to be challenged; trying to make a significant push; combining endurance, flexibility and strengthening routines; desiring to do more; accomplishing more; wanting to feel the burn; improving endurance, flexibility and strengthening; obsessing about workout'; preferring to be challenged; exploring new routines; stepping up the game; falling short of expectations	Challenging mentality; tiredness infusing more PA; hectic schedule forcing PA; being out of breath is an impetus to do more; celebration of success; hoping for challenges; complement all domains of exercise; pushing oneself; resolutions; mixing high and low intensities; past failures; unattainable tasks; result of effort; gauging capability and ability; intensity levels; overcoming tiredness; understanding capabilities; need for variety;
Easy access to resources	Benefitting from good trainers; cheaper online programs; committing to a PT; challenging situations at the gym; stimulating confidence from coaches in person or virtually; relying on expert recommendations; being able to PA anywhere and anytime; flexibility of schedule, space and equipment;	Dedication; distasteful gym environments; pushing by coaches; convenience; exciting interface and equipment; distractions at home; flexibility of choice and schedule; routine tasks; worrying about tasks; greater resolve

Enjoying outdoors	Enjoying the weather; desiring solitariness; organizing messy outdoors; doing PA away from home; preferring outdoorsy activities; doing outdoor activities subconsciously leading to fitness; preferring strenuous work; combining outdoor and indoor activities	Excitement, improvement, inspiring, interesting, inclination to do more, overriding tiredness, improvement, encouragement due to visual delight, presentable outdoors, overcoming challenges, combining tasks
Experience	Feeling good; improving energy levels; increasing excitement levels; inspiration to do more; internalizing the need to do more; overcoming laziness	Be energetic; inspired feeling; overcome inertia to do nothing; work against gravity; meet goals
Fear of being unhealthy	Self-awareness; recognizing deficiencies; fearing inability; empathizing with family member; realizing need for being healthy	getting stale; awareness of deficiencies; to be active; mortality; balance; overweight; poor health; sedentariness; ability to walk; poor health;
Focussing on appearance	Accepting of body shape; maintaining waist size; desiring weight loss; improving physical shape; toning of muscles; obsessing about weight; exercising for slimming	Lose weight; distasteful body shape; "waist" management; tempered body; excitement, feeling of weight loss; tangible results of slimming, belt size, weight, waist size; satisfaction; irritability of shape (body)
Focussing on motivational affordances	Allure of accomplishments; quantifying PA; inspiring achievements; remembering to do PA; tracking feedback	Badges, points, stars, medals, slogans, clapping, images, challenges, rewards, tracking; bell, text, note, ring; feedback, weights, progress, effort, posture; virtual trainer
For a healthy lifestyle	Accepting of body challenges; being active; working towards activities; understanding the benefits; understanding limitations; preferring an active lifestyle; overcoming sedentariness; improving health goals; optimizing mind and body	Lack of flexibility; outdoor and indoor activities; endurance, mobility, flexibility, good health, relaxation, training muscles, energy levels, live longer, optimal health; poor health, getting stale; short bursts of activity many times;
Freedom of usage	Persisting to doing correctly; Accepting of doing PA; prioritizing schedule, space and activity; adapting easily; freedom of affordances	Understanding steps and timing; scheduling possibilities; flexibility of doing PA anywhere; simplicity of instructions; variety, sound, voice command, interface; timers
Fun and recreation	Creating time to do PA; committing to variety; intergenerational activity; combining locations and equipment; enjoying outdoors; enjoying different types of PA; improving one's perspective; enjoying spontaneity	Making time; getting it done; swimming with grandchildren; walking, gardening, swimming; different location; not a chore, activity for fun, game type; sudden bursts of activity
Influenced by the app	Using it anywhere anytime; appreciation of ability;	Flexibility of doing the exercise routines; being able to do the PA; simplicity; combine

	challenging routines; correcting posture; comparing with peers; influencing to do more; complimenting endurance and strengthening; committing to a schedule; following through on work done; providing companionship; reviewing effort and progress; proving ability of doing PA; easing remembrance of routines; inspiring technology	with gym, endurance and strengthening; eight-week routine, daily short bursts, compare with spouse, companion (virtual trainer), routine challenges; easy recall, simplicity;
Inspirational influencers	Inspiring to do PA; performing at a high level; understanding desire to excel; remembering past laurels; playing team sports	Experts, knowledge, family members, good teachers, coaches, doctors, online experts, online training, younger individuals, physiotherapists,
Limitations of resources	Incurring expenses; training by PT; changing routines; failing at the gym; intimidating gym environment; continuing with same routines; scheduling challenges; planning leading to failure; dieting is a challenge; self-monitoring of challenges	Expensive; reluctance; discouragement; difficulty in waking up; inability to keep up; partners to play; food cravings; limited freedom at the gym; lack of interest in fixed routines
Mental wellbeing	Changing attitude; stimulating physical and mental wellbeing; reliving freedom from exercise equipment; disappointing intensities; feeling unable to do more; tempering one's mind; being true to oneself; reaching a cruising state; overcoming laziness; overcoming low energy levels; feeling of satisfaction; relying on values; persevering to continue; relaxing virtues; reflecting on the self	Desire to improve; lower stress; intensity levels; discouragement; fearful of boredom, inability, failure, commitment issues; overcoming guilt; achieving a state; lethargy, inertia, anxiety, venting; praise, feeling better, pleasure; past glory, laurels, achievements, habits; combination of simple routines; overcoming a lull feeling, resolve to do more, inspirational; confidence from past
Routine/Lifestyle	Accommodating routines; committing to a schedule; challenging daily routines; forming a habit; working with routines; balancing routines;	New and old routines; schedule flexibility; regular activities; changes in routines; past training; self-regulation, self-monitoring; consistency of schedule; high and low intensities
Social connections	Encouraging interactions; making social connections; comparing ability with others; seeking group connections	group activities, spouse, friends, team, presence of others, familiar people; younger persons; overcoming tiredness; encouragement; companionship; online connections; walking, bike riding, golfing, hockey, gym; sharing, satisfaction; distracting relatives
Spontaneous and subconscious activity	Exciting spontaneous activities; preferring to do household activities	excitement about on the spur of the moment; activities leading to exercises;

Treatment for a health issue	Overcoming health challenges; worrying about taking pills; desiring weight loss; improving health condition; being self-aware of challenges	Bad knees, obesity, shape, posture, back problems, hip condition, quintuplet bypass, scoliosis; stiff and immobile, unbalanced and frozen, allergic reactions, passing away of friends and family, fatigue, dehydration, blood pressure.
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13.9.1.2 Motivation for PA: Group 2

Axial code	Open code	Properties and associated concepts
Accomplishing a goal	Accomplishing challenges with ease; desiring to do something; inspiring situations; comparing results; persevering to put effort; understanding the benefits of PA	Yard work, exercising, goals; competing with spouse; reach former fitness levels, targets, goals, lack of PA inspiring more PA; overcome low energy, better awareness
Challenged by activity	Challenges of burnout; boring gym routines; reluctance for competitions; desiring to achieve set targets; desire to feel tired and spent; preferring to be challenged than a slow climb; challenging technology adaptations	Boredom; lack of patience; non-stop yard work; do challenging activities; overcome failures
Enjoying outdoors	Enjoying good weather; preferring outdoorsy activities; feeling like playing outdoor sports; doing outdoor activities subconsciously leading to fitness	Excitement; playing; cottage activities; yard work, walking
Experience	Feeling good; improving energy levels; inspiration to do more; doing more routine movements	Energetic; energy levels; routine activities
Fear of being unhealthy	Realizing need for being healthy	Overcome sitting; forced movement
Focussing on appearance	Desiring weight loss; shaping up for a vacation; toning the body; unhappy with obesity	Weight, shape, slim down, obesity
Focussing on motivational affordances	Quantifying PA; inspiring achievements; remembering to do PA; tracking feedback	Tracking; weight, steps, calories
For a healthy lifestyle	Accepting of importance of PA; being fit and healthy; being active; desiring good health; understanding the benefits of PA; improving health goals	Acceptance; fit, healthy; active, flexible, good health, independent, mobile;
Fun and recreation	Overcoming boring routines at the gym	boredom
Influenced by artifact	Influencing quality of artifact	Pedometer readings inspired to do more
Inspirational influencers	Inspiring to do PA	Influenced by younger persons
Limitations of resources	Overcoming challenging weather situations; continuing with same routines	Inclement weather forcing to do more treadmill; overcome mundane routines
Mental wellbeing	Overcoming feeling of guilt; overcome sedentary feeling; feeling of satisfaction; reflecting	Eating a lot; lower stress levels; opinions of others; sedentary; tiredness is a good feeling; prior successes; self-monitoring

	on the self; inspiring past laurels; feeling of elation	
Routine/Lifestyle	Committing to a schedule; challenging daily routines; forming a habit	Daily routine; consistent schedules; becomes a habit
Social connections	Making social connections; comparing ability with others; seeking group connections	Peers, spouse, team, walking group; enjoyment
Spontaneous and subconscious activity	Exciting spontaneous activities; preferring to do household activities	Watching news and exercising; doing household activities
Treatment for a health issue	Overcoming health challenges; desiring weight loss; improving health condition; being self-aware of challenges	Overweight, obesity, depression; weight loss pain, sickness, illness; torn hip muscle, knee, scoliosis

13.9.1.3 Motivation for PA: Group 3

Axial code	Open code	Properties and associated concepts
Accomplishing a goal	Accomplishing challenges with ease; persevering to put effort; understanding the benefits of PA	Doing tedious outdoor activity; doing PA at own pace; inspired to put in time; inspired to do morning workouts
Challenged by activity	Desiring to achieve set targets; trying to make a significant push; persevering on a routine; desiring to be challenged	Pushing to achieve something; excitement; competition; combine indoor and outdoor activities
Enjoy outdoors	Enjoying good weather; preferring outdoorsy activities; doing outdoor activities subconsciously leading to fitness	Weather; outdoor activities like golfing, jogging and running; do more household and outdoor activities;
Fear of being unhealthy	Realizing need for being healthy	Afraid of being unfit; fear of illness
Focussing on Motivational affordances	Quantifying PA	Tracking weight and steps; calories and steps; heart rate and stress
For a healthy lifestyle	Being fit and healthy; being active; desiring good health; understanding the benefits of PA; improving health goals	Have a healthy life; be healthy and active; be more mobile; lead a normal life; good life
Fun and recreation	Changing scenarios; availability of time for PA	Retirement; freedom
Mental wellbeing	Improving self-confidence; overcoming laziness	Laziness, self-confidence
Routine/Lifestyle	Committing to a schedule; challenging daily routines; forming a habit	Excitement; regular routines; habit formation; set schedule inspiring regular PA
Social connections	Making social connections; seeking group connections	Making it a social activity; workout in groups
Treatment for health issue	Desiring weight loss; improving health condition	Experts recommendations; health conditions

13.9.2 Setting up Goals

13.9.2.1 Group 1

Theme	Open Code	Properties and associated concepts
Combining exercise types	Combining endurance, flexibility and strengthening; combining low, medium and high intensity; combining household and outdoorsy activities	Sports and exercise routines; high and low intensity; indoor and outdoor activities
Committing time for activity	Booking time for routines; committing time to others; enrolling in a program	Flexibility; schedule; availability
Enjoying combination of activities	Participating in competitions; combining indoor and outdoor activities; working towards a scheduled routine; encouraging results increased PA	Walkathons, swimming, sporting activity, exercise routines, household activity, outdoorsy activities; scheduled tasks; encouragement due to success
Focussing on goals	Working towards results; curious for progression; improving confidence and interest; preparing for competitive activity	Daily goals; weight loss; strength in arms; endurance; overcome sitting; balance and flexibility; improving posture; overcoming lethargy/laziness; upper body strength
Focussing on appearance	Improving waist size; slimming down	“Waist” management; body shape
Focussing on motivational affordances	Getting stars and points; increasing intensity due to results; increasing step count; inspiring activity by penalties; checking off activities; progressing towards goals	Stars and points; results and intensity; penalties or negative points; pecking order, list; progression
Improving health outlook	Realizing potential to do more; being active and mobile; resolving to do more; overcoming lethargy;	Benefits; past laurels; fit and mobile; interests; laziness
Increasing challenges progressively	Building up step by step; increasing targets; improving fitness levels; pushing hard for more achievements	Weights, muscle groups, daily step targets, stamina, time taken, goals; higher intensities; switching intensities easily; improvement; hitting targets; making it interesting
Self-regulating routines	Programming schedule for activities; working towards healthy lifestyle; maintaining interest through variety	Be fit and healthy, being flexible, exiting the home; limited time availability; personal routines; virtual coach; failure leading to PA; watching videos; planning; deadline; perfecting; consistent correctness of routines; being accustomed, being familiar
Social interaction	Engaging in social activity types; comparing progression;	Walkathons, socialize, group exercises, common goal, comparing within group, spouse;
Spontaneous and subconscious activity	Feeling spontaneity of action; Working on household activities leading to PA	Not being forced, subconscious activity

13.9.2.2 *Setting up Goals: Group 2*

Axial code	Open Code	Properties and associated concepts
Combining exercise types	Combining household and outdoorsy activities	Sports and exercise routines; high and low intensity; indoor and outdoor activities
Focussing on goals	Working towards results; improving confidence and interest;	small goals; weight loss; reducing back pain; overcome sitting; balance and flexibility; outdoor activities; upper body strength
Focussing on motivational affordances	Progressing towards goals; increasing step count; inspiring activity through achievements; checking off activities;	tracking; results and intensity; achievement points; progression
Improving health outlook	Realizing potential to do more; resolving to do more	Benefits; osteoporosis; fit and mobile; interests;
Increasing challenges progressively	Building up step by step; increasing targets; pushing hard for more achievements	Adding routines, activities, steps, goals; hills and challenges; switching intensities easily; improvement; hitting targets; doing more
Self-regulating routines	Programming schedule for activities; reflecting on self; maintaining interest through variety	Be fit and healthy, personal routines; planning; deadline; perfecting; consistent monitoring of diet
Social interaction	Engaging in social activity types; comparing progression;	Workout with partner, group exercises, loneliness, comparing within group, spouse;

13.9.2.3 *Setting up Goals: Group 3*

Axial code	Open Code	Properties and associated concepts
Combining exercise types	Combining household and outdoorsy activities	Sports and exercise routines; high and low intensity; indoor and outdoor activities
Focussing on goals	Working towards results	weight loss; overcome sitting; balance and flexibility; outdoor activities
Focussing on motivational affordances	Progressing towards goals; increasing targets	tracking; step count, results and intensity; progression
Improving health outlook	Realizing potential to do more; feeling good	Benefits; healthy, fit and mobile, longevity; lower cholesterol
Self-regulating routines	Programming schedule for activities; reflecting on self; maintaining interest through variety	Be fit and healthy, personal routines; planning; watching routines; perfecting; consistent monitoring of diet
Social interaction	Engaging in social activity types; comparing progression;	Walk with partner, group activity, loneliness, comparing within group, spouse;

13.9.3 **Feeling of Accomplishment in PA**

13.9.3.1 *Group 1*

Theme	Open Code	Properties and associated concepts
Adding new challenges	Increasing challenges to existing routines; replacing existing routines with new ones; being	Increasing flexibility; increasing frequency, endurance, flexibility, strengthening exercises; indoor and outdoor activities

	able to combine types of activities	
Influencing activity through app	Realizing deficiencies through app; being able to do better; feeling energetic	arm strength, ability, improving flexibility, app helped identify deficiencies, more energy
Completing difficult challenges	Being able to do vigorous activities, completing difficult tasks	Increased intensity, completed hectic activity, outdoor and indoor activities; yard work, swimming, hockey exercise routines, app routines
Feeling of mental satisfaction	Feeling happy and satisfied; feeling better; wanting to do more	Tiredness feels good; felt like pushing to do more; feeling content; trying harder; satisfaction of completion
Feeling the burn	Doing a good workout, changing attitude	Having done something, burn in the muscles, attitude
Feeling validated for efforts	Being energetic, feeling happy; feeling of increased energy	No complaints, commitment forces effort, felt good
Improving body conditioning	Getting results; relaxing of body; improving awareness about body	Tighter muscles, toning, maintaining weight, loosening of body; flexibility routines; posture improvement; upper body strength; better breathing
Improving confidence	Reaching targets; sense of achievement; giving it the best shot	Increase points target; confidence of abilities; wall push-ups; feeling like being able to do more; becoming easier to do;
Improving health condition	Overcoming health situations	Making pain go away, sleep better, relieve sore back issues, hip movement, posture improvement
Improving ability	Increasing targets or goals	Higher weights, loosens body, able to do it on one's own; feeling good to do higher intensities, able to do upper body workout; becoming easier; wall push-ups, challenging routines, able to improve posture, relaxed pace; able to touch toes; faster timing; do for longer time; feeling of missing out on PA;
Increasing independence	Being able to do more easily; doing it anywhere and anytime; flexible combination of indoor and outdoor activities;	Becoming easier, faster and longer durations, changing routines easily
Inspiring motivational affordances	Reassuring effort by rewards; achieving targets	Praise, compliments, progress bar, rewards, stars, points; completion of tasks; progression through challenges; redeeming points; visual representation of efforts, step targets, distance walked
Inspiring performance	Feeling like doing better each time; trying more; reaching greater targets; curious to see end result; feeling like continuing; overcoming laziness	Better, happy, doing more; pushing oneself; age appropriate movements; reaching peak ability; complimented on performance by others
Progressing through activities	Completing tasks; accomplishing a lot; combining intensities and types of exercises	Reminders; adding challenges; doing routines; happy with progression information;
Seeking external resources	Seeking recommendations	Fitness consultant; yoga instructors

Social interaction	Making social connections	Working in groups; working well with people
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13.9.3.2 Accomplishment in PA: Group 2

Axial code	Open Code	Properties and associated concepts
Adding new challenges	Increasing challenges to existing routines; replacing existing routines with new ones; being able to combine types of activities	Trails, hills and valleys, increasing steps, endurance and flexibility, intensity of exercises; indoor and outdoor activities
Completing difficult challenges	Being able to do vigorous activities, completing difficult tasks	Outdoor activities; household activities; walking, increasing step count, golfing
Feeling of mental satisfaction	Feeling happy and satisfied; feeling better; wanting to do more	Tiredness feels good; felt like pushing to do more; feeling content; energetic; feeling fit; satisfaction of completion
Feeling the burn	Doing a good workout, changing attitude	Burn some fat
Improving body conditioning	Getting results; relaxing of body; improving awareness about body	Bringing weight down, toned muscles, increased stamina, better posture
Improving confidence	Reaching targets; sense of achievement; giving it the best shot	confidence of abilities; feeling like being able to do more; becoming easier to do; physically fit for age
Inspiring motivational affordances	Reassuring effort by rewards; achieving targets	Progression of activities; increase in step count; cut back on wine; increased calorie burn
Progressing through activities	Completing tasks; accomplishing a lot; combining intensities and types of exercises	adding challenges; doing routines; happy with progression information; completed daily steps; meeting targets
Social interaction	Working with people	Competing with spouse; comparing progress

13.9.3.3 Accomplishment in PA: Group 3

Axial code	Open Code	Properties and associated concepts
Adding new challenges	Increasing challenges to existing routines; being able to combine types of activities	Moving neighbour's lawn, training for ½ marathon, being busy
Completing difficult challenges	Being able to do vigorous activities, completing difficult tasks	Outdoor activities; household activities; walking, increasing step count, golfing
Feeling of mental satisfaction	Feeling happy and satisfied; feeling better	Feeling energetic, enthusiastic; happy to do neighbours work; felt relaxed; happiness from doing it; completing it; being fit
Improving body conditioning	Getting results; improving awareness about body	Better physique; feeling healthier; peace of mind; more stamina
Improving confidence	Reaching targets; sense of achievement; giving it the best shot	Maintaining endurance and strengthening activities; being able to do it,

Improving health condition	Overcoming health situations	Controlling sugar levels; lowering BP; heart rate
Improving ability	Increasing targets or goals	Combining household and outdoor activities; doing tasks well; better endurance
Progressing through activities	Completing tasks; accomplishing a lot; combining intensities and types of exercises	doing routines; completed ½ marathon; maintaining endurance; met daily targets; doing as planned; regimented status; completed outdoorsy projects
Social interaction	Working with people	Played sports; play with younger persons;

13.9.4 Fears and Barriers

13.9.4.1 Group 1

Theme	Open Code	Properties and associated concepts
Challenging health conditions	Fearing changes in health; aging issues; balance issues	Biopsy, cancer check, obesity, shoulder injury, knee challenges, ligament tears, posture, gait check, shingles scare, pain
Fearing inability	Fearing not being mobile; inability to do things on one's own; avoidance rather than doing; maintain good health;	Inability, immobile, fear of injury, challenges of good health,
Fearing appearance issues	Changing shape; defining body features	Broad waist; flabby belly, bad posture
Having psychological challenges	Lacking mental and physical drive; feeling weak; feeling failure; lacking commitment	Low energy levels; low inclination; psychologically weak; tiredness; lack of accomplishment; commitment issues; invasion of privacy; making excuses not to do PA
Limiting resources	Limiting spatial challenges; temporal challenges; equipment challenges	Gym environment, home environment; time; finances; technology usage;
Fearing lack of performance	Being aggressive; being obsessive about details;	Overestimating and falling short; preparing for a future activity; pain
Fearing social interaction	Fearing group activities; Connecting with people	Too pushy, different goals, needing to be alone

13.9.4.2 Fears and Barriers – Group 2

Theme	Open Code	Properties and associated concepts
Challenging health conditions	Fearing changes in health; aging issues; balance issues	Weight gain, allergies, arthritis, gout,
Fearing inability	Fearing not being mobile; inability to do things on one's own;	Inability, immobile, fear of injury; fear of poor health
Fearing appearance issues	Changing shape; defining body features	Overweight, lack of posture
Having psychological challenges	Lacking mental and physical drive; feeling weak; feeling failure;	Low energy levels; low inclination; balance issues; psychologically weak; tiredness; weakening strength; being dependent on

		kids; unable to do enough; loneliness, companionship
Limiting resources	Limiting spatial challenges; temporal challenges; equipment challenges; environmental challenges	Weather, Gym environment, home environment; time; finances; technology usage;
Fearing lack of performance	Overdoing it; unable to push further	Being out of breath, difficult routines

13.9.4.3 Fears and Barriers - Group 3

Axial code	Open Code	Properties and associated concepts
Challenging health conditions	Fearing changes in health; aging issues; balance issues	Weight gain, allergies, arthritis, gout,
Fearing inability	Fearing not being mobile; inability to do things on one's own;	Lack of mobility; unable to do things; losing independence
Fearing appearance issues	Changing shape; defining body features	Broad waist; flabby belly
Having psychological challenges	Lacking mental and physical drive; feeling weak; feeling failure;	Laziness; being dependent on kids; unable to do enough; loneliness, companionship
Limiting resources	Limiting spatial challenges; temporal challenges; equipment challenges; environmental challenges	Weather, Gym environment, home environment; time; finances; technology usage;
Fearing lack of performance	Overdoing it; unable to push further	Lacking independence; inactivity; flexibility and strength issues

13.9.5 Rewards and PA

13.9.5.1 Group 1

Theme	Open Code	Properties and associated concepts
Completing an activity	Being like a game; feeling of relief; reaching daily targets;	Daily routines, tasks, exercises, step targets; victory in completion; points target, step target, correct and consistent completion;
Having freedom of usage	Discovering new abilities; having flexibility of usage	Curiosity; Anywhere anytime, while boiling eggs, in pyjamas, did not feel like it
Having intangible rewards	Achieving targets; feeling of doing well; complimenting situations	Reaching 30k/day, sincere praise, feeling important, more energy, good; not wanting outside gratification; gaining knowledge; getting easier, satisfaction of completion; short-term, long term rewards;
Having tangible rewards	Getting something out of activity	Unchanged belt buckle position, different sceneries, weight loss, looking better; wine, beer, chocolates; smell the flowers; lower caloric intake (food);
Feeling of mental satisfaction	Experiencing different feelings	Feeling good, better, less tired, visual improvement; easy remembering of activities; minimizing pain;

Having self-awareness	Understanding deficiencies;	Lack of arm strength, lack of good posture, unable to do any push-ups; weakness in areas
Having sense of accomplishment	Recognising achievements	Increased intensity routines; amazing feeling of completion; feeling the burn, burn in legs; not winded when climbing stairs; feeling relaxed
Improving confidence	Feeling of doing more; being able to do different type of exercises; trying out different things;	Trying Strength training; flexibility exercises; combinations
Influencing characteristics of the app	Noticing benefits; being a companion	Easy remembering of routines; noticing feeling stronger; bragging rights (wall push-ups); virtual companion; really helping with understanding deficiencies and possible improvements
Improving health condition	Being more flexible; having better awareness; wanting to do better	Conscious of posture; improving posture; not being out of breath; increased flexibility
Inspiring motivational affordances	Feeling rewarded	Progression, points, stars, badges, progress bar, goals, levels; praise, compliments; check-points, scratching of a list; task completion, having rules, redeeming points, monthly comparisons; overcoming discouragement; validation of efforts
Seeing results of efforts	Tracking indicates results of efforts;	Burning calories, reaching points, steps target, meeting; reassurance to be on the plan (program); felt like purchasing exercise equipment with metrics; activity leads to exercise subconsciously
Social activity	Working with people	Transgenerational activity; competing, influence with spouse; working for and with loved ones
Uninspiring motivational affordances	Stressing over rewards	Not competitive today, too stressful, obsessing over food, points is bad,

13.9.5.2 Rewards and PA - Group 2

Axial code	Open Code	Properties and associated concepts
Completing an activity	Completing tasks; reaching daily targets;	Combining household and outdoorsy tasks, basement renovation, step targets, gardening, walking, golfing, feeling relaxed
Having intangible rewards	Achieving targets; feeling of doing well	Feeling energetic; vibrant and having a good feeling
Having tangible rewards	Getting something out of activity	different sceneries, weight loss, looking better; wine, beer, cake, chocolates; smell the flowers; lower caloric intake (food);
Feeling of mental satisfaction	Experiencing different feelings	Feeling good, better, making it work; Feeling energetic, like doing more
Having self-awareness	Understanding deficiencies;	Feeling of discipline; overcoming laziness; wanting to do more
Having sense of accomplishment	Recognising achievements	Getting things done; increasing intensities; moving from one level to next; sticking to challenges

Improving confidence	Feeling of doing more; trying out different things;	Felt like doing more; feeling competent
Improving health condition	Being more flexible; having better awareness; wanting to do better	Blood pressure and sugar level is under control; feeling more vibrant
Inspiring motivational affordances	Feeling rewarded	Progression, points, belt like in karate, monthly comparisons; overcoming discouragement; validation of efforts
Seeing results of efforts	Tracking indicates results of efforts;	Step count, calorie burn, distance
Social activity	Working with people and animals	Competing, influence with spouse; working for and with pets
Uninspiring motivational affordances	Stressing over rewards	Do not want to be rewarded by points

13.9.5.3 Rewards and PA - Group 3

Axial code	Open Code	Properties and associated concepts
Completing an activity	Completing tasks; reaching daily targets;	Completing tasks correctly; completing the ½ marathon, maintaining garden; housekeeping; basement preparation;
Having intangible rewards	Feeling of doing well	Feeling energetic; happy with a feeling of enthusiasm; sincere praise
Having tangible rewards	Getting something out of activity	Great sceneries, weight loss, looking better; wine, beer, ice-cream, scotch, eating out (restaurant), cake, chocolates; smell the flowers; lower caloric intake (food);
Feeling of mental satisfaction	Experiencing different feelings	Feeling good, feeling content; satisfaction from completion; meeting daily targets; feeling relaxed
Having self-awareness	Understanding deficiencies;	Feeling of discipline; overcoming laziness; wanting to do more
Having sense of accomplishment	Recognising achievements	Being able to lead a normal life; elation at completing the ½ marathon; happy and contend; enjoyment of participation
Improving health condition	Leading a normal life; having better awareness	Blood pressure and sugar level is under control;
Inspiring motivational affordances	Feeling rewarded	Progression, points, badges, monthly comparisons; step count indicates effort
Seeing results of efforts	Tracking indicates results of efforts;	Step count, calorie burn, distance
Social activity	Working with people	Running with a partner
Uninspiring motivational affordances	Stressing over rewards	Do not want to be rewarded by points

13.9.6 Tracking of PA

13.9.6.1 Group 1

Theme	Open Code	Properties and associated concepts
Challenging tracking issues	Feeling anxiety due to numbers, challenged with technology; punishing oneself with numbers	Invasive technology, slaves to technology, not concerned with numbers; low phone usage; inputting data is painful
Indicating completion status	Feedback for completion; monitoring feeling	Checkmark, clapping, energy level; praise, compliments
Improving body form	Tracking posture; helping to correct form; improving confidence	Like a mirror, form checker, waist size, synchronizing body movements and required movements
Indicating motivational affordances	Indicating achievements; personalizing messages information	Time duration, checking off a list; leaderboards, progression, comparison with others, effort meter; points redemption; personalizing dialogue and text; improvement in numbers is promising
Making social connections	Comparing progress or lack of; making connections; learning from others	Giving confidence; you are not alone; learning, sharing
Needing feedback	Types of feedback; checking posture; attaining goals; prompting activity; progressing through the week and through activity	Voice driven, music, bell, small talk, ease of use and companionship, reminders, notes regarding progress, correcting posture; inactivity; virtual coach
Measuring physical activity	Changing body activity; tracking progression; comparing with others	Weight, steps, calorie burn, calorie intake, distance, HR, time taken, diet, effort (can this be tracked), progression; achievement levels, points earned, score, comparison

13.9.6.2 Tracking of PA – Group 2

Theme	Open Code	Properties and associated concepts
Challenging tracking issues	Feeling anxiety due to numbers, challenged with technology; punishing oneself with numbers	Inactive time tracking; low numbers; not fixated by numbers
Indicating completion status	Feedback for completion; monitoring feeling	Distance completed; distance to go
Improving body form	Tracking posture; correcting form; improving confidence	form checker, posture/gait information
Indicating motivational affordances	Indicating achievements	Steps and distance measure
Making social connections	Comparing progress or lack of; making connections	Comparing with others
Needing feedback	Types of feedback; checking posture; attaining goals; prompting activity; progressing through the week and through activity	Weight loss, shape checker, lower numbers

Measuring physical activity	Changing body activity; tracking progression; comparing with others	Weight, weight loss pattern; steps, calorie burn, calorie intake, distance, HR, pulse rate; cholesterol levels, sugar levels; time taken, diet, effort (can this be tracked), progression; achievement levels, points earned, score, comparison; breathing patterns;
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13.9.6.3 Tracking of PA – Group 3

Theme	Open Code	Properties and associated concepts
Indicating completion status	Feedback for completion; monitoring feeling	Distance completed; distance to go
Improving body form	Tracking weight and body shape	form checker, weight
Making social connections	Comparing progress or lack of; making connections	Comparing with others
Needing feedback	Types of feedback; checking posture; attaining goals; prompting activity; progressing through the week and through activity; making it a habit	Weight loss, shape checker, numbers
Measuring physical activity	Changing body activity; tracking progression; comparing with others	Weight, weight loss pattern; steps, calorie burn, calorie intake, distance, speed, HR, pulse rate; cholesterol levels, sugar levels; time taken, diet, effort (can this be tracked), progression; achievement levels, points earned, score, comparison; breathing patterns;

13.10 Phase 4: Quantitative Results

13.10.1 Friedman's ANOVA (PNSE and IMI)

Test Statistics ^a	
1 N	80
Chi-Square	44.540
df	2
Asymp. Sig.	.000
Exact Sig.	.000
Point Probability	.000
2 N	80
Chi-Square	66.576
df	2
Asymp. Sig.	.000
Exact Sig.	.000
Point Probability	.000
3 N	80
Chi-Square	80.309
df	2
Asymp. Sig.	.000
Exact Sig.	.000
Point Probability	.000

a. Friedman Test

Table 122: Test Statistics - Friedman's ANOVA (PNSE)

Test Statistics ^{a,b}	
1 N	
Chi-Square	222.069
df	6
Asymp. Sig.	.000
2 N	80
Chi-Square	286.404
df	6
Asymp. Sig.	.000
3 N	80
Chi-Square	274.599
df	6
Asymp. Sig.	.000

a. Some or all exact significances cannot be computed because there is insufficient memory.

b. Friedman Test

Table 123: Test Statistics - Friedman's ANOVA (IMI)

13.10.2 Overall Tests between Groups

Kruskal-Wallis Test (PNSE)

Kruskal-Wallis Test Statistics^{a,b}			
	Perceived Competence	Perceived Autonomy	Perceived Relatedness
Chi-Square	28.772	8.760	17.598
df	2	2	2
Asymp. Sig.	.000*	.013*	.000*

a. Kruskal Wallis Test (PNSE), b. Grouping Variable: Please input your Group Number

Table 124: Kruskal-Wallis Test (PNSE)

Jonckheere-Terpstra Test (PNSE)^a			
	Perceived Competence	Perceived Autonomy	Perceived Relatedness
Number of Levels in Please input your Group Number	3	3	3
N	240	240	240
Observed J-T Statistic	6491.500	9804.500	8064.000
Mean J-T Statistic	9600.000	9600.000	9600.000
Std. Deviation of J-T Statistic	582.930	561.794	584.120
Std. J-T Statistic	-5.333	.364	-2.630
Asymp. Sig. (2-tailed)	.000*	.716	.009*

a. Grouping Variable: Please input your Group Number

Table 125: Jonckheere-Terpstra Test (PNSE)

Kruskal-Wallis Test (IMI)**Kruskal-Wallis Test Statistics^{a,b}**

	Perceived				Perceived		
	Interest/Enjoyment	Competence	Effort/Importance	Pressure/Tension	Choice	Value/Usefulness	Relatedness
Chi-Square	12.449	39.650	6.209	12.558	12.500	6.428	10.421
df	2	2	2	2	2	2	2
Asymp. Sig.	.002*	.000*	.045*	.002*	.002*	.040*	.005*

a. Kruskal Wallis Test (IMI), b. Grouping Variable: Please input your Group Number

Table 126: Kruskal-Wallis Test (IMI)

Jonckheere-Terpstra Test^a

	Interest/Enjoyment	Perceived Competence	Effort/Importance	Pressure/Tension	Perceived Choice	Value/Usefulness	Relatedness
	Number of Levels in Please input your Group Number	3	3	3	3	3	3
N	240	240	240	240	240	240	240
Observed J-T Statistic	7602.500	5824.000	8272.500	8590.500	11616.500	8116.000	8919.000
Mean J-T Statistic	9600.000	9600.000	9600.000	9600.000	9600.000	9600.000	9600.000
Std. Deviation of J-T Statistic	584.005	584.153	583.621	574.022	584.131	569.488	582.607
Std. J-T Statistic	-3.420	-6.464	-2.275	-1.759	3.452	-2.606	-1.169
Asymp. Sig. (2-tailed)	.001*	.000*	.023*	.079	.001*	.009*	.242
Effect size	-.221	-.417	-.147	-.114	.223	-.168	-.075

a. Grouping Variable: Please input your Group Number

Table 127: Jonckheere-Terpstra Test (IMI)

13.10.3 Follow-up Tests

Mann-Whitney Test (PNSE)

Gamified (Group1) – Non-gamified (Group 2):

Ranks (PNSE)				
Please input your Group				
	Number	N	Mean Rank	Sum of Ranks
Perceived Competence*	1	80	91.23*	7298.50
	2	80	69.77	5581.50
	Total	160		
Perceived Autonomy	1	80	88.51	7081.00
	2	80	72.49	5799.00
	Total	160		
Perceived Relatedness*	1	80	93.94*	7515.00
	2	80	67.06	5365.00
	Total	160		

*Significance at $p < 0.0167$

Table 128: Mann-Whitney Test (PNSE) - Group 1 - Group 2

Test Statistics^a			
	Perceived Competence	Perceived Autonomy	Perceived Relatedness
Mann-Whitney U	2341.500	2559.000	2125.000
Wilcoxon W	5581.500	5799.000	5365.000
Z	-2.954	-2.276	-3.689
Asymp. Sig. (2-tailed)	.003	.023	.000
Exact Sig. (2-tailed)	.003*	.023	.000*
Exact Sig. (1-tailed)	.001	.011	.000
Point Probability	.000	.000	.000

a. Grouping Variable: Please input your Group Number

Table 129: Test Statistics- Mann Whitney Test (PNSE) Group 1 - Group 2

Gamified (Group1) – Control (Group 3):

Ranks (PNSE)				
Please input your Group				
	Number	N	Mean Rank	Sum of Ranks
Perceived Competence*	1	80	100.13*	8010.50
	3	80	60.87	4869.50
	Total	160		
Perceived Autonomy	1	80	79.82	6385.50
	3	80	81.18	6494.50
	Total	160		
Perceived Relatedness*	1	80	92.36*	7389.00
	3	80	68.64	5491.00
	Total	160		

*Significance at $p < 0.0167$

Table 130: Mann-Whitney Test (PNSE) - Group 1 - Group 3

Test Statistics^a			
	Perceived Competence	Perceived Autonomy	Perceived Relatedness
Mann-Whitney U	1629.500	3145.500	2251.000
Wilcoxon W	4869.500	6385.500	5491.000
Z	-5.382	-.196	-3.249
Asymp. Sig. (2-tailed)	.000	.845	.001
Exact Sig. (2-tailed)	.000	.846	.001
Exact Sig. (1-tailed)	.000	.423	.001
Point Probability	.000	.001	.000

a. Grouping Variable: Please input your Group Number

Table 131: Test Statistics- Mann Whitney Test (PNSE) Group 1 - Group 3

Non-Gamified (Group2) – Control (Group 3):

Ranks (PNSE)				
Please input your Group				
	Number	N	Mean Rank	Sum of Ranks
Perceived Competence	2	80	88.99	7119.50
	3	80	72.01	5760.50
	Total	160		

Perceived Autonomy*	2	80	70.61	5649.00
	3	80	90.39*	7231.00
	Total	160		
Perceived Relatedness	2	80	74.40	5952.00
	3	80	86.60	6928.00
	Total	160		

*Significance at $p < 0.0167$

Table 132: Mann-Whitney Test (PNSE) - Group 2 - Group 3

	Test Statistics ^a		
	Perceived Competence	Perceived Autonomy	Perceived Relatedness
Mann-Whitney U	2520.500	2409.000	2712.000
Wilcoxon W	5760.500	5649.000	5952.000
Z	-2.333	-2.806	-1.669
Asymp. Sig. (2-tailed)	.020	.005	.095
Exact Sig. (2-tailed)	.019	.005	.095
Exact Sig. (1-tailed)	.010	.002	.048
Point Probability	.000	.000	.000

a. Grouping Variable: Please input your Group Number

Table 133: Test Statistics- Mann Whitney Test (PNSE) Group 2 - Group 3

Mann-Whitney Test (IMI)

Gamified (Group1) – Non-gamified (Group 2):

	Ranks (IMI)			
	Please input your Group Number	N	Mean Rank	Sum of Ranks
Interest/Enjoyment	1	80	84.01	6721.00
	2	80	76.99	6159.00
	Total	160		
Perceived Competence	1	80	91.59*	7327.50
	2	80	69.41	5552.50
	Total	160		
Effort/Importance	1	80	86.47	6917.50
	2	80	74.53	5962.50
	Total	160		
Pressure/Tension	1	80	74.38	5950.50

	2	80	86.62*	6929.50
	Total	160		
Perceived Choice	1	80	71.61	5729.00
	2	80	89.39	7151.00
	Total	160		
Value/Usefulness	1	80	84.79	6783.00
	2	80	76.21	6097.00
	Total	160		
Relatedness	1	80	91.18*	7294.50
	2	80	69.82	5585.50
	Total	160		

*Significance at $p < 0.0167$

Table 134: Mann-Whitney Test (IMI) - Group 1 - Group 2

	Test Statistics ^a						
	Interest/Enjoyment	Competence	Effort/Importance	Pressure/Tension	Perceived Choice	Perceived Value/Usefulness	Perceived Relatedness
Mann-Whitney U	2919.000	2312.500	2722.500	2710.500	2489.000	2857.000	2345.500
Wilcoxon W	6159.000	5552.500	5962.500	5950.500	5729.000	6097.000	5585.500
Z	-.964	-3.040	-1.636	-1.691	-2.433	-1.213	-2.956
Asymp. Sig. (2-tailed)	.335	.002*	.102	.091	.015*	.225	.003*

a. Grouping Variable: Please input your Group Number

Table 135: Test Statistics- Mann Whitney Test (IMI) Group 1 - Group 2

Gamified (Group1) – Control (Group 3):

	Ranks (IMI)			
	Please input your Group Number	N	Mean Rank	Sum of Ranks
Interest/Enjoyment	1	80	92.98	7438.50*
	3	80	68.02	5441.50
	Total	160		
Perceived Competence	1	80	101.98	8158.50*
	3	80	59.02	4721.50
	Total	160		
Effort/Importance	1	80	89.90	7192.00*
	3	80	71.10	5688.00

	Total	160		
Pressure/Tension	1	80	85.98	6878.00
	3	80	75.03	6002.00
	Total	160		
Perceived Choice	1	80	68.00	5440.00
	3	80	93.00	7440.00*
	Total	160		
Value/Usefulness	1	80	88.88	7110.00
	3	80	72.13	5770.00
	Total	160		
Relatedness	1	80	86.26	6901.00
	3	80	74.74	5979.00
	Total	160		

*Significance at $p < 0.0167$

Table 136: Mann-Whitney Test (IMI) - Group 1 - Group 3

Test Statistics ^a							
	Perceived			Perceived			
	Interest/Enjoyment	Competence	Effort/Importance	Pressure/Tension	Choice	Value/Usefulness	Relatedness
Mann-Whitney U	2201.500	1481.500	2448.000	2762.000	2200.000	2530.000	2739.000
Wilcoxon W	5441.500	4721.500	5688.000	6002.000	5440.000	5770.000	5979.000
Z	-3.415	-5.878	-2.576	-1.546	-3.421	-2.354	-1.576
Asymp. Sig. (2-tailed)	.001*	.000*	.010*	.122	.001*	.019	.115

a. Grouping Variable: Please input your Group Number

Table 137: Test Statistics- Mann Whitney Test (IMI) Group 1 - Group 3

Non-Gamified (Group2) – Control (Group 3):

Ranks (IMI)				
	Please input your Group			
	Number	N	Mean Rank	Sum of Ranks
Interest/Enjoyment	2	80	89.48	7158.00*
	3	80	71.53	5722.00
	Total	160		
Perceived Competence	2	80	95.13	7610.00*

	3	80	65.88	5270.00
	Total	160		
Effort/Importance	2	80	81.73	6538.00
	3	80	79.28	6342.00
	Total	160		
Pressure/Tension	2	80	93.76	7501.00*
	3	80	67.24	5379.00
	Total	160		
Perceived Choice	2	80	76.68	6134.50
	3	80	84.32	6745.50
	Total	160		
Value/Usefulness	2	80	86.39	6911.00
	3	80	74.61	5969.00
	Total	160		
Relatedness	2	80	72.57	5805.50
	3	80	88.43	7074.50
	Total	160		

*Significance at $p < 0.0167$

Table 138: Mann-Whitney Test (IMI) - Group 2 - Group 3

Test Statistics^a

	Perceived		Perceived				
	Interest/Enjoyment	Competence	Effort/Importance	Pressure/Tension	Choice	Value/Usefulness	Relatedness
Mann-Whitney U	2482.000	2030.000	3102.000	2139.000	2894.500	2729.000	2565.500
Wilcoxon W	5722.000	5270.000	6342.000	5379.000	6134.500	5969.000	5805.500
Z	-2.458	-4.005	-.336	-3.695	-1.047	-1.642	-2.182
Asymp. Sig. (2-tailed)	.014*	.000*	.737	.000*	.295	.101	.029

a. Grouping Variable: Please input your Group Number

Table 139: Test Statistics- Mann Whitney Test (IMI) Group 2 - Group 3

13.11 Phase 5: Expert Evaluation Questions and Results

13.11.1 Questionnaire for Heuristics Evaluation

Heuristics for Gamification Applications (HEG): Adapted from Tondelo et al. (Tondello, Kappen, et al., 2016)

Intrinsic Motivation Questions

Purpose and Meaning	IM1	P1	Does the system provide enough context for the user to understand the benefits (to themselves or to others) of what they are doing?
	IM2	P2	Does the system provide information that allows the user to reflect on their real-life achievements and how to improve themselves outside of the system?
Challenge and Competence	IM3	CC1	Does the system present challenges in a way that motivates the user to tackle them?
	IM4	CC2	Is the difficulty of the challenges adjusted to the user's ability and skill?
	IM5	CC3	Do the challenges' difficulty increase over time?
	IM6	CC4	Does the system present an initial tutorial or explanation of the first steps the user should take?
	IM7	CC5	Is the tutorial or initial explanation challenging and fun?
Completeness and Mastery	IM8	CC6	Does the system offer features to allow the user to create their own challenges?
	IM9	CM1	- Does the system always present a new goal right after the user completes the current goal?
	IM10	CM2	- Are the suggested new goals immediately achievable (adequate to the user's ability and skill)?
	IM11	CM3	Are the suggested new goals always a bit more difficult than the previous?
	IM12	CM4	- Does the system allow the user to keep track of their achievements and/or completed goals?
Autonomy and Creativity	IM13	CM5	Is the achievement tracking meaningful, i.e., does it help the user understand which new abilities or skills were acquired after each achievement or what rewards were awarded?
	IM14	AC1	- Does the system let the user freely choose their goals and tasks?
	IM15	AC2	- Does the system offer multiple paths for achieving similar results?
	IM16	AC3	- Does the system present choices that are adequate for the user's ability and skills (i.e. don't present too many choices at the beginning when the user does not understand all the choices)?

	IM17	AC4	Does the system clearly inform the user about the available choices and their consequences?
	IM18	AC5	- Does the system let the user create new content for themselves or other users?
	IM19	AC6	Does the system let the user express themselves (e.g. avatars, personalized pages, status messages, etc.)?
	IM20	AC7	Does the system offer multiple paths for achieving similar results?
	IM21	AC8	Does the system let the user experiment with different paths without fear or serious consequences (e.g. they can go back and follow another path if the experiment does not work)?
Relatedness	IM22	R1	Does the system offer means for the user to interact with other users?
	IM23	R2	Are social interactions meaningful for the application, i.e., do they help users achieve their goals?
	IM24	R3	- Does the system offer means for users to work together towards achieving common goals?
	IM25	R4	Are users adequately rewarded proportionally to the effort they invested in the collaborative work?
	IM26	R5	Does the system offer means for users to compare themselves with others?
	IM27	R6	Does the system offer means for users to compete or challenge other users?
	IM28	R7	Is progression in the system balanced and fair, i.e., do all users have equal chance of achievement if they put the same effort and time into the system?
	IM29	R8	Do the system offer means for newcomers to progress at their own pace without feeling diminished by the progress of other users that are already ahead of them?
Immersion	IM30	I1	Does the system feature a theme or story that provides an aesthetic experience?
	IM31	I2	Is the theme or story meaningful and connected to the users' goals?
	IM32	I3	Is the theme or story clearly explained?
	IM33	I4	Does the system allow the user to interact with and influence the story?
	IM34	I5	Does the system allow for fun (as in enjoyment) when interacting with the system?
	IM34	I6	Does the system allow for fun (as in engagement) when interacting with the system?

Extrinsic Motivation

Ownership and Rewards	EM1	OR1	Does the system feature an individual profile that the user can evolve over time?
	EM2	OR2	Does the system let users own virtual goods?
	EM3	OR3	Are the user profile and/or virtual goods meaningful and useful to the user?
	EM4	OR4	Is progression of the user profile or acquisition of virtual goods a result of the user's progression in the system?
	EM5	OR5	Does the system reward the user for completing tasks or progressing in their goals?
	EM6	OR6	Does the system reward the user for continued use?
	EM7	OR7	Are rewards proportional to the amount of effort, time, and dedication that the user put into the system?
	EM8	OR8	Are the rewards meaningful and useful for the user?
	EM9	OR9	Does the system let the user exchange their rewards or possessions with other users?
	EM10	OR10	Does the system let the user exchange their rewards or possessions for other virtual goods?
	EM11	OR11	Does the system let the user exchange their rewards or possessions for outside (real-life) rewards?
Scarcity	EM12	S1	Does the system offer rewards or virtual goods that are rare or difficult to obtain?
	EM13	S2	Does the system limit certain features only to users with certain accomplishments?
	EM14	S3	Does the system let users display the rare or difficult goods or rewards that they have obtained?
	EM15	S4	Is the difficulty of obtaining such rare goods or rewards proportional to the amount of effort and time invested into the system?
Loss Avoidance	EM16	LA1	Does the system feature timed tasks, which make the user lose an opportunity if they are not completed in time?
	EM17	LA2	Does the user feel they are going to lose something unless they keep using the system continually (e.g. rewards for continued use, information, social connections, etc.)?
	EM18	LA3	Does the system make the user feel that they should keep using the system due to the amount of time or effort already invested?
Context Dependent			
Feedback	CD1	F1	Does the system immediately inform the user when any change in status occur?

	CD2	F2	Does the system immediately inform the user when any task is completed or any goal is achieved?
	CD3	F3	Is the feedback always clear and understandable?
	CD4	F4	Does the feedback always explain exactly what has happened and which action caused it?
	CD5	F5	Does the system immediately inform the user what are the next available actions after any task is completed or any goal is achieved?
	CD6	F6	Does the system always inform how the next available actions are connected to the completed action?
	CD7	F7	Does the system always clearly inform the user where they stand in progression and possessions?
	CD8	F8	Does the system immediately inform which is the next step in progression that can be achieved and how to achieve it?
	CD9	F9	Does the system always inform which are the obtainable rewards or virtual goods and how to obtain them?
Unpredictability	CD10	U1	Does the system feature any unexpected variability in the tasks or goals that can be completed (e.g. by randomly suggesting a different goal)?
	CD11	U2	Does the system award unexpected rewards for achievements or progression (e.g. by partly randomizing the rewards obtained for a completed task or goal)?
	CD12	U3	Does the user feel they can influence their chance of getting better random rewards?
Change and Disruption	CD13	CD1	Does the system let the user create new content for themselves or other users?
	CD14	CD2	Can the system be modified by the user in any way (e.g. by changing the system directly or through plugins or mods)?
	CD15	CD3	Can the users contribute with ideas or suggestions?
	CD16	CD4	Can the users influence in the system's evolution (e.g. by voting in their preferred new features)?
	CD17	CD5	Is the system protected against cheating?
	CD18	CD6	Is the system protected against hacking?
	CD19	CD7	Does the system protect users from harassment from other users?
	CD20	CD8	Does the system limit the user's ability to gain unfair advantages over other users by any means?
Long Form Questions		LF1	Do you think any specific gamification elements/motivational affordances/game elements should be given higher importance than others?

	LF2	In your expert opinion, what other gamification elements/motivational affordances/game elements would be more impactful in the context of the Spirit50 application?
	LF3	Do you think that the application provided adequate feedback to the participants?
	LF4	If feedback provided in the Spirit50 application was not adequate, can you suggest any pointers to improve the feedback to potential users?
	LF5	From an expert evaluation perspective, please list a few limitations of the Spirit50 application, if any?
	LF6	From the perspective of older adults, can you suggest ways to improve this application?
	LF7	Do you see any major hindrances in implementing Spirit50 application for older adults (over 50 years of age) in the context of Physical Activity and challenges caused due to aging?
	LF8	Do you see any usability challenges with this application in context of older adults (over 50 years of age) physical activity and challenges caused due to aging?
	LF9	From an older adult's perspective, do you think that the Spirit50 application could provide the opportunity of challenges and achievement in the form of exercise variations and/or levels of exercise intensities?
Usefulness	S1	On a scale of 1 (worst) to 5 (best), how would you rate the usefulness of the Spirit50 Application
Easiness	S2	On a scale of 1 (worst) to 5 (best), how would you rate the easiness to use of Spirit50 Application
Clarity	S3	On a scale of 1 (worst) to 5 (best), how would you rate the clarity of Spirit50 Application

13.11.2 Content Analysis of Long-form Questions

Question LFI

Expert Evaluator Code	Do you think any specific gamification elements/motivational affordances/game elements should be given higher importance than others? (Analysis)	Attributes
EX01	app is centered around goal achievement affordances related with competence and mastery should be given priority	Focus on goal achievement; priority on competence and mastery
EX03	There is an interface issue i.e. Rewards are not highlighted enough Progress bar does not appear to fill Other extrinsic gamification elements are not easily visible and hence quite compelling Getting in shape is something that the users of the site are pursuing themselves I didn't feel that the system was giving me any added incentive to continue interacting with it perhaps new information like diet and health goals achieved and to be achieved (benefits of doing these ones)	Rewards were not highlighted enough; progress bar did not seem to progress; gamification elements were not easily visible; getting in shape was a norm; no added incentive from system;
EX04	don't entirely understand what you do with the points	Usage of points
EX05	collaborative and non-competitive elements should be given higher importance	Increase collaborative and non-competitive elements
EX07	stars and points should be made more visible these are the only rewards (extrinsic) that you get for completing the exercises users should be able to comment on each other's performance express themselves favourably (or not) regarding others feats users should be able to produce content for others this would help develop a community to motivate each other to reach their goals	Visibility of stars and points Rewards for completing tasks Comment on others performance Express themselves favourably Produce content for others Build a community to motivate
EX08	social features should not be given high importance features that increase the ability of elderly people should be given high importance	Facilitate increase in ability Downplay social features
EX11	completion of goals, ability to do meet the goals	Ability to meet goals Completion of goals

Expert Evaluator Code	Do you think any specific gamification elements/motivational affordances/game elements should be given higher importance than others? (Analysis)	Attributes
EX12	mastery of doing the tasks, performance, ability to do the tasks	Mastery of doing tasks Showcase performance Ability to do tasks
EX20	challenges of clarity badge and point system could work hard to understand the dynamics on how to get these rewards a progress assessment would be good, showing progress they have achieved points systems could work a simple progress graph would be helpful (for older people) perhaps progress/performance chart can indicate dynamics of rewards (i.e. if user gets to a certain level within the progress bar, they will obtain a reward)	Challenges with clarity of directions Lack of understanding of reward dynamics Showcase progress assessment Reward system could work Showcase progress graph Progress graph and reward mechanics

Question LF2

Expert Evaluator Code	In your expert opinion, what other gamification elements/motivational affordances/game elements would be more impactful in the context of the Spirit50 application? (Analysis)	Attributes
EX01	Elements related with socialization would probably have a high impact on users elements related with autonomy would give users more choice to customize their program Elements related with randomness could create fun moments through unexpected events or activities	Increased socialization Increase choice fostering autonomy Interject randomness for fun Interject unexpected events
EX03	Schedule is cute and pathway through the exercises is straightforward outside that interaction loop, user-centric features are pretty lacking "I received only a star for completing all daily exercises" points seem meaningless because I don't see any progress towards a goal or another level	Add user-centric features Increase rewards mechanics and dynamics for effort Exaggerate progression

Expert Evaluator Code	In your expert opinion, what other gamification elements/motivational affordances/game elements would be more impactful in the context of the Spirit50 application? (Analysis)	Attributes
EX04	Learning about more exercises and how they make muscle groups stronger	Impart learning Impart onboarding
EX05	the same elements should not be presented to each user type (with different motivational affordances) and those that have some complexity (health issues)	Customized affordances to health complexities
EX07	stars and points should be made more visible users should be able to comment on each other's performance express themselves favourably (or not) regarding others feats users should be able to produce content for others this would help develop a community to motivate each other to reach their goals	Greater visibility of rewards Increased commenting options Express sentiments (+ve or -ve) Content producers Social fitness community
EX08	social features should not be given high importance features that increase the ability of elderly people should be given high importance	Facilitate increase in ability Downplay social features
EX11	Gamification elements when finishing all exercises of that day.	Showcase daily task completion
EX12	A progress bar would be good to add when undertaking the daily workouts After completing the first few I wanted to know how many exercises I had left to go before I was finished for the day.	Progression in daily workouts Balance workouts to daily roadmap
EX20	a performance/progress bar would be useful to allow users to compare their performance against others Maybe a leaderboard of some sort would be helpful website should also improve the personal profile capability You want the user to feel like they have a profile that they need to maintain within the platform Right now is too simplistic and not motivational at all	Performance progress bar Compare progression with others Presence of leaderboards Personal profile (avatars) Ownership of personalize profile Overcome simplicity of design

Question LF3

Expert Evaluator Code	Do you think that the application provided adequate feedback to the participants?	Attributes
EX01	The app provided a schedule, a point's counter, and a progress toward goal, which were good. However, the feedback could be clearer.	Feedback regarding performance
EX03	Feedback was not adequate	Feedback regarding effort was inadequate
EX04	animations on timer were okay	Feedback was OK
EX05	I think it does not have enough feedback for users. Accordingly, the importance of feedback and guidance is greater for older people.	Greater guidance for older people Feedback regarding progress
EX07	The stars are points are the only reward for completing challenges. they are barely visible I barely noticed the star was there after completing my exercises. After completing a whole day of work, it remained on the 0%. Also, progress bars inside exercise, jump abruptly to 50% on start and then to 100% when the exercise ends.	Increased visibility of rewards Accentuate rewards Exaggerate progress Proportionate movement of progress against work done
EX08	Sometimes it wasn't clear what was supposed to happen or what should be done by the user. I expected something to happen after starting the timer for an exercise but apparently, I had to stop the timer myself. I also expected the # of reps' counter to do something.	Improved on-screen instructions Correctness of timer Expectations of rep counter
EX11	Feedback is not always very clear. For example, when you can enter your own challenges, you do not see them added in your list and it is not clear what happens with your suggestion. In the user profile, when clicking the name, it looks like you clicked, but nothing happens, thus no clear feedback given.	Feedback on challenges (tasks) is unclear Clickable buttons must change color as feedback of clicked action

Expert Evaluator Code	Do you think that the application provided adequate feedback to the participants?	Attributes
EX12	<p>It would be good to explain why each exercise is important. What is good about doing squats? How will they help me?</p> <p>In addition to this it would be good to provide more images to show how the exercise is done (and have them clickable if possible) and then have the video there only if needed (turning off auto play would be good as I can imagine after doing it once the video the auto play would be a little annoying).</p> <p>The points were explained a little but more information could be provided, also I couldn't find where to use them for a discount.</p> <p>The profile logout button wasn't obvious, maybe replace the x with 'logout' to give better feedback to the user.</p>	<p>Explain importance of exercises</p> <p>Add information on benefits</p> <p>Add slide show</p> <p>Video start should be optional</p> <p>Increased clarity of rewards mechanism</p> <p>Improved logout procedure</p>
EX20	<p>I think the feedback of the platform is really poor. It is really hard to understand how the platform works, how the rewards are obtained.</p> <p>There are technical difficulties with running the videos (I used a MAC - Safari).</p> <p>Feedback is a key element for engagement, the lack of feedback disconnects the user from the platform.</p>	<p>Improve feedback on the system</p> <p>Improve feedback of rewards mechanism</p> <p>De-bug cross-platform issues</p> <p>Lack of feedback = lack of engagement</p>

Question LF4

Expert Evaluator Code	If feedback provided in the Spirit50 application was not adequate, can you suggest any pointers to improve the feedback to potential users? (Analysis)	Attributes
EX01	<p>what is the contribution of each exercise toward the goal?</p> <p>why these particular exercises were selected for me and not others?</p> <p>how many points each exercise award?</p> <p>what can I do with points (are they just for show)?</p>	<p>Contributions of exercises towards goal</p> <p>Value of specificity of exercise selection</p> <p>Quantify rewards to types of exercises</p> <p>Additional use of rewards</p>

Expert Evaluator Code	If feedback provided in the Spirit50 application was not adequate, can you suggest any pointers to improve the feedback to potential users? (Analysis)	Attributes
EX03	<p>Visibility is terrible, especially considering your target audience.</p> <p>there are some good motivational elements included in the design but they are not evident to the user.</p> <p>I'd recommend not showing the user the recommended intensity of their work out until all existing fitness has been filled out- could be intimidating.</p> <p>Progress needs to be clear outside of the exercise schedule.</p> <p>Points, stars, whatever, need to be meaningful in some way.</p>	<p>Accentuate motivational elements</p> <p>Emphasize rewards</p> <p>Emphasize fitness intensity based on health condition</p> <p>Improve clarity of progress bar</p> <p>Usage of rewards for other purposes</p>
EX04	<p>explain why the timer start and stop buttons are provided</p>	<p>Improved explanation of timers</p>
EX05	<p>Status changes</p> <p>Consequences of actions</p> <p>Sense of actions</p> <p>Relevant triggers for new challenges</p>	<p>Emphasize status changes (levels/weekly progression)</p> <p>Ownership of actions</p> <p>Value of health benefits as triggers for new challenges</p>
EX07	<p>progress bars and points so be made better visible and maybe animated to take the user's attention.</p> <p>Users should have a dashboard which would gather feedback and display some info visual views.</p>	<p>Emphasize rewards and progression</p> <p>Elaborate dashboard for feedback and infographics</p>
EX08	<p>Maybe it would help if the user had to perform the exercise together with the person in the video</p> <p>Nothing is stopping the user from pressing the start button, doing nothing and pressing the stop button again (to make it seem he/she performed the exercise in a short timeframe).</p>	<p>Possibility of cheating</p> <p>Synchronize exercise with person in the training video</p>
EX11	<p>add explanation on why the exercise is important</p> <p>suggest improvements to form and correctness of form</p>	<p>Emphasize value of specific routines</p> <p>Emphasize form correction</p>

Expert Evaluator Code	If feedback provided in the Spirit50 application was not adequate, can you suggest any pointers to improve the feedback to potential users? (Analysis)	Attributes
EX12	<p>It would be good to break the timer down into the different sets. So timing the different sets and then asking to track what I did or used (e.g., used 3kg dumb bells).</p> <p>This would help then to give me a sense of progress over time if I could see how I was improving.</p> <p>I wasn't sure what the progress bar does as well in the "Workout Weekly Schedule" page. It would be good to provide more information about this.</p>	<p>Include tracking of effort</p> <p>Synchronize effort with progression</p>
EX20	<p>Based on the target population of this platform I think users should constantly be provided with feedback and guidance about how to do things on the platform.</p> <p>The platform should offer formative and summative feedback.</p> <p>The engagement of this population will increase based on the amount of "achievements" they feel they get on the website</p> <p>simple things like setting up their goals and challenges correctly should be mentioned to them.</p> <p>The idea of constant iterative feedback to increase motivation and engagement could really help with the type of population.</p>	<p>Provide micro feedback</p> <p>Provide formative and summative feedback</p> <p>Ownership of achievements</p> <p>Explain reasoning for set goals and challenges</p> <p>Iterative feedback is important for this demographic</p>

Question LF5

Expert Evaluator Code	From an expert evaluation perspective, please list a few limitations of the Spirit50 application, if any?	Attributes
EX01	<p>however, users are limited to only one choice; what if they have more than one health issue?</p> <p>Additionally, goals could be transformed in sub goals (e.g. I want to have more energy, ok, but how can this goal be split into weeks, for example, so that I can understand what the exercises I do each week will help me achieve).</p> <p>Furthermore, as I stated above, I felt feedback could be improved, and elements regarding relatedness, autonomy, and unpredictability could be added.</p>	<p>Limitations of one choice at a time</p> <p>Limitations of sub goals</p> <p>Limitations of feedback</p> <p>Incorporate social collaboration, increased choice (autonomy) and unpredictability</p>

Expert Evaluator Code	From an expert evaluation perspective, please list a few limitations of the Spirit50 application, if any?	Attributes
EX03	improve the visibility of the points and start show a graph of where their goal is and where they are now	Limitation that rewards were not emphasized enough
EX04	there are many competing sites available, so would people pay for this service?	Many competitor sites
EX05	Personalization of engagement Engagement cycle Social environment Collaborative environment	Limitations of feedback Lack of social environment Lack of collaborative environment
EX07	It fails to portray feedback. It adapt to users with different needs and preferences. - It fails to onboard users. They are just asked a bunch of questions and then land on the schedule. On the third stop "Your current health", some of the quest could be shown	Limitations of feedback Fails to onboard users Show a few quests at initial stages to generate curiosity
EX08	I think it's useful to have a point system but it wasn't clear what I could do with my points. Did I use points to select goals? Or did selecting goals result in added points?	Lack of information on what to do with the rewards collected Using rewards for opening new quests
EX11	Optimise logging in for the primary use and use a modal view when you have to enter your credentials. Keep important information above the fold of the page and make sure a user can see that there is more content, otherwise, they probably will not scroll down the page.	Need to over emphasize profile and login and logout for demographic
EX12	From what I can tell it isn't obvious to see how I'm progressing over time using the app and working towards achieving my goal. The website doesn't resize well for mobile phones which some people might use to access the site when working out. It may be good to make it more mobile-friendly.	Lack of clarity on progression versus time to goal achievement Lack of responsive design Multi-platform device deployment is critical for this demographic

Expert Evaluator Code	From an expert evaluation perspective, please list a few limitations of the Spirit50 application, if any?	Attributes
EX20	<p>Limitations regarding gamification: The target population of the platform has little experience with new technologies.</p> <p>This population conceptualizes games in a different way that younger populations do.</p> <p>I understand game elements are generic. However, the implementation of those game elements in a virtual environment should be done with the supervision of the target population.</p> <p>Adding game elements to the platform with the aim of increasing motivation and engagement can also be limited by the user understanding on the game elements.</p> <p>If the user does not understand the elements they will have no effect on how the user uses/interacts with the platform</p> <p>Limitations regarding the system: The system is a new experience for the target population. The first limitation will be access to the system.</p> <p>The second one will be their knowledge regarding "how to use the system." The target population is not technology savvy.</p> <p>Therefore, it is important to provide a throughout tutorial of how to use the platform to the users.</p> <p>The exercises suggested in the platform will require some room for the user to complete them. Users can lose motivation to use the platform if they feel that they cannot watch the videos on the platform and perform the exercises right away.</p> <p>Especially since the platform offers the time tracking capability, which implies that the exercises should be completed close to the computer running the system.</p>	<p>Limitations with technology</p> <p>Challenges with conceptualization of games for this demographic</p> <p>Limitations due to knowledge of game elements across this demographic</p> <p>Limitations for accessible systems</p> <p>Limitation on knowledge to use the system (not tech savvy)</p> <p>Training/onboarding challenges</p> <p>Constraints of space</p> <p>Preference for mobile platforms to computer desktops</p>

Question LF6

Expert Evaluator Code	From the perspective of older adults, can you suggest ways to improve this application? (Analysis)	Attributes
EX01	add benefits of doing the routines needs to be more simplified add more choices add comments on why these are important to do	Emphasize benefits of activity Simplify interaction add choices to foster autonomy
EX03	Accessibility considerations as noted Better access to information on how to use the site Clear feedback, working progress meter-context for points, stars-	Ease of feedback Improve information on th value of site Improve feedback on rewards and progression
EX04	Mobile application, most grandparents are more likely using a mobile phone then a desktop these days.	Multi-platform Mobile platforms
EX05	Greater guidance Simplification of the environment Usability improvements Personalization (towards exercise scheduling) Sense of belonging to a group	Increase guidance Simplify interface Showcase value of improvements Social collaboration
EX07	more feedback on the value of the exercises where will this get me? What improvements will I have?	Emphasize value of the site Emphasize goal achievement Emphasize potential improvements
EX08	Maybe mark what costs and gains points by making the number green or red. Add some kind of feedback during the exercises.	Simplify explanations of rewards Provide real-time feedback when exercising
EX11	Avoid using all capital letters because this makes it harder for them to read a text. Radio buttons have a small hit target, which makes it difficult for them to click. Use bigger hit areas.	Resolve font size Resolve hit area of radio buttons
EX12	It would be good to see the overall workout plan. Provide some variability in the exercises and allow people to track their progress and make notes on how they went.	Showcase the entire eight-weeks on a graph Provide variation in exercises

Expert Evaluator Code	From the perspective of older adults, can you suggest ways to improve this application? (Analysis)	Attributes
EX20	<p>the application should be more intuitive.</p> <p>Older adults would likely have less patience, and you do not want to overload them.</p> <p>The interaction with the system should feel natural and effortless.</p> <p>More guidance, as well as constant messages for completing simple steps, will help the user to engage with the platform.</p>	<p>Improved repeatability and memorability of exercises</p> <p>Reduce login challenges</p> <p>Add more guidance for doing more</p> <p>scaffolding of progress</p> <p>constant encouragement with messaging</p>

Question LF7

Expert Evaluator Code	Do you see any major hindrances in implementing Spirit50 application for older adults (over 50 years of age) in the context of Physical Activity and challenges caused due to aging? (Analysis)	Attributes
EX01	challenges with technology for this demographic	Challenges with technology adaptation
EX03	older people and technology	Older people and technology
EX04	safety issues during the exercises, who will be responsible	Safety issues when exercising
EX05	I do not see any hindrance	
EX07	educating /onboarding of the technology prior to usage there should be a demo animation to show what is going on and what will be the potential outcome	Onboarding of technology usage
EX08	No major hindrances	
EX11	older people have lesser patience and getting them to click on buttons may be a challenge	<p>Lack of patience (older adults)</p> <p>Challenges with controllers</p>

Expert Evaluator Code	Do you see any major hindrances in implementing Spirit50 application for older adults (over 50 years of age) in the context of Physical Activity and challenges caused due to aging? (Analysis)	Attributes
EX12	<p>More information may need to be provided about the exercises, explaining why they are important and tracking how the users are doing.</p> <p>It may also be important to provide alternative exercises in case of any injuries or disabilities.</p>	<p>More details of value of exercises</p> <p>Explanation of importance</p> <p>Challenges of real-time feedback</p> <p>Challenges for real-time exercise change due to injuries</p>
EX20	<p>A concern I had while using the platform is that the user will be expected to complete the exercises on its own. One of the main physical limitations of the elderly population is their balance; I was wondering if there is any way to make sure that the platform will not be prompting the user to complete exercises that might cause an injury. I understand it is an online platform, but maybe it should be only used while at the gym or under the supervision of someone else. Safety, in this case, is my main concern for this type of population.</p> <p>The second major hindrance for me is engaging a population that is not too familiar with technology in general, into using a technology based platform. I'm not saying it is not possible, but it will be a challenge.</p>	<p>Concern with exercising on one's own</p> <p>Challenges with balance</p> <p>Minimizing injury due to exercises</p> <p>Deployment in a supervised environment</p> <p>Concerns for safety</p> <p>Lack of familiarity with technology</p>

Question LF8

Expert Evaluator Code	Do you see any usability challenges with this application in context of older adults (over 50 years of age) physical activity and challenges caused due to aging? (Analysis)	Attributes
EX01	bigger font size, icons may need explanations	Interface design

Expert Evaluator Code	Do you see any usability challenges with this application in context of older adults (over 50 years of age) physical activity and challenges caused due to aging? (Analysis)	Attributes
EX03	Accessibility considerations as noted Better access to information on how to use the site Clear feedback, working progress meter-context for points, stars	Value of importance of this site Clear feedback on regression and rewards
EX04	there could be issues with mouse clicks and stopping and doing exercises	Challenges with controller (mouse)
EX05	yes, less text information would be better	Interface design
EX07	it may be better to start small and then add more complexities however, they should not get bored	Gradual increase in exercise intensity Minimize boredom
EX08	Maybe the interface is too complicated for elderly people. For example, the screen with the exercise schedule could have a button to start the exercises or a piece of texts that explains to the user that they can start an exercise. It seemed that the boxes next to each exercise were meant for selecting which subset of exercises I wanted to start.	Interface design Improved information to start and stop an exercise
EX11	coordinating with buttons, and their ability to do things on their own	Lack of coordination
EX12	As long as standard controls and interaction design patterns are used I can't see any usability challenges with the application. It would be good not to have the videos autoplay (instead allow users to play them if they want for increased autonomy).	No usability issues with design Choice of auto play for videos

Expert Evaluator Code	Do you see any usability challenges with this application in context of older adults (over 50 years of age) physical activity and challenges caused due to aging? (Analysis)	Attributes
EX20	<p>I think the usability challenges can be overruled if the platform is created for mobile devices.</p> <p>The elderly population might not be familiar with how to use a computer, but nowadays is probably easier for them to learn how to use a tablet (i.e., iPad) instead of a computer, plus it is more versatile, lighter and easy to carry around.</p> <p>Developing a mobile version of the app will help to overcome the intrinsic usability challenges that elderly population would have when interacting with a techy based platform.</p>	<p>Challenges can be overruled if deployed on mobile devices</p> <p>Easier to use tablets instead of a desktop/laptop</p> <p>Increased portability</p> <p>Mobile version to overcome technology challenges</p>

Question LF9

Expert Evaluator Code	From an older adult's perspective, do you think that the Spirit50 application could provide the opportunity of challenges and achievement in the form of exercise variations and/or levels of exercise intensities? (Analysis)	Attributes
EX01	Yes, with increased options/choices for increasing competence and mastery,	With increased autonomy, competence and mastery
EX03	I think it provides it but as discussed, I think there are several barriers to its actual usability and communication of meaningfulness to users	With improvements in feedback for rewards and progression
EX04	could be a good tool, to help older people at a reduced cost	Could be a good tool, cost effective
EX05	this could provide challenges and achievement to older adults, but difficulty level must increase	Difficulty level must increase
EX07	it can be a good platform, but safety, onboarding and challenge levels are important,	Add educational, training and onboarding content
EX08	Yes, I think it can help to have a varied exercise schedule.	Yes, a varied plan will help

Expert Evaluator Code	From an older adult's perspective, do you think that the Spirit50 application could provide the opportunity of challenges and achievement in the form of exercise variations and/or levels of exercise intensities? (Analysis)	Attributes
EX11	As older adults often want to remain in a good shape, I think an application like this one can help them to do exercises on their pace, keeping in mind their problems or health issues.	Will foster being in good shape Can help to foster health and wellbeing
EX12	Yes, I think the idea is good but a few things about the website could be improved further. The gamification doesn't provide a great drawcard just yet but could be improved with a few minor tweaks. It would be good to run a study with the target user group and see what they think of it.	Gamification elements can be added and/or improved
EX20	I feel that if the level of difficulty is going to increase to provide challenges and achievement-base engagement, the only concern I would have is to present the user with a level of difficulty that could cause an injury due to the intrinsic physical limitations of the elderly population. Presenting the challenges, and getting users to achieve them will definitely contribute to user engagement with the platform.	Increase in difficulty to increase in engagement Challenges due to injuries Challenges due to physical limitations Achievement of challenges to foster engagement

13.11.3 Cronbach's Alpha

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.921	.936	17

Table 140: Heuristics for Evaluating Gameful Applications (HEG) - Cronbach's Alpha

13.11.4 Cronbach's Alpha with Dimensions Deleted

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Purpose and Meaning	65.4657	437.487	.354	.922
Challenge and Competence	64.8917	436.416	.662	.919
Completeness and Mastery	64.4213	410.220	.851	.913
Autonomy and Creativity	66.0769	419.138	.843	.914
Relatedness	65.5074	388.700	.771	.911
Immersion	65.5213	417.772	.527	.918
Extrinsic Motivation- Ownership	64.7713	406.143	.611	.916
Extrinsic Motivation- Rewards	65.3824	402.373	.810	.912
Extrinsic Motivation-Virtual Economy	66.9472	381.871	.554	.922
Extrinsic Motivation-Scarcity	65.2157	370.554	.806	.910
Extrinsic Motivation-Loss Avoidance	66.0213	417.176	.426	.921
Context Dependent- Feedback	65.8824	399.135	.799	.912
Context Dependent- Actionable Feedback	65.3546	430.771	.381	.921
Context Dependent- Graspable Progress	65.9472	404.034	.849	.912
Context Dependent- Unpredictability	66.6139	395.859	.676	.914
Context Dependent- Innovation	66.7991	398.898	.564	.918
Context Dependent- Disruption Control	64.1880	395.428	.586	.918

Table 141: Cronbach's Alpha with Dimensions Deleted

13.11.5 Pearson's Correlation

Correlation (<i>r</i>)	CC	CM	AC	R	I	EM-O	EM-R	EM-V	EM-S	EM-LA	CD-F	CD-A	CD-G
Autonomy and Creativity (AC)	.708*	.812*											
Relatedness (R)		.851*											
Immersion (I)		.675*											
Extrinsic Motivation-Ownership (EM-O)		.685*											
Extrinsic Motivation-Rewards (EM-R)		.942**	.851**	.698**	.721*	.767**							
Extrinsic Motivation-Virtual Economy (EM-V)				.858**									
Extrinsic Motivation-Scarcity (EM-S)		.703*	.738*	.831**				.855**					
Extrinsic Motivation-Loss Avoidance (EM-LA)													
Context Dependent-Feedback (CD-F)		.700*	.793*				.817**						
Context Dependent-Actionable Feedback (CD-A)					.807**								
Context Dependent-Graspable Progress (CD-G)			.696*								.767*	.673*	
Context Dependent-Unpredictability (CD-U)				.712*					.789*				.780*

Correlation (r)	CC	CM	AC	R	I	EM-O	EM-R	EM-V	EM-S	EM-LA	CD-F	CD-A	CD-G
Context Dependent-Innovation (CD-I)										.674*			
Context Dependent-Disruption Control (CD-D)						.682*							

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

13.11.6 Usefulness, Easiness and Clarity

Descriptive Statistics								
	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
[How would you rate the USEFULNESS of the Spirit50 Application?] Please select an answer	9	3	3	6	4.56	.377	1.130	1.278
[How would you rate the EASINESS to use of Spirit50 Application?] Please select an answer	9	3	1	4	3.22	.364	1.093	1.194
[How would you rate the CLARITY of Spirit50 Application?] Please select an answer	9	4	1	5	2.89	.484	1.453	2.111
Valid N (list wise)	9							

Table 142: Expert Evaluation - Usefulness, Easiness and Clarity

13.12 Ethics Approvals

13.12.1 Approval 1

Date: April 28, 2016
To: Dennis Kappen
From: Shirley Van Nuland, REB Chair
REB # & Title: (15-102) Survey Study for Gamified Physical Activity
Decision: APPROVED
Current April 01, 2017
Expiry:

Notwithstanding this approval, you are required to obtain/submit, to UOIT's Research Ethics Board, any relevant approvals/permissions required, prior to commencement of this project.

The University of Ontario, Institute of Technology Research Ethics Board (REB) has reviewed and approved the research proposal cited above. This application has been reviewed to ensure compliance with the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS2 (2014)) and the UOIT Research Ethics Policy and Procedures. You are required to adhere to the protocol as last reviewed and approved by the REB.

Continuing Review Requirements (forms can be found on the [UOIT website](#)):

- **Renewal Request Form:** All approved projects are subject to an annual renewal process. Projects must be renewed or closed by the expiry date indicated above ("Current Expiry"). Projects not renewed within 30 days of the expiry date will be automatically suspended by the REB; projects not renewed within 60 days of the expiry date will be automatically closed by the REB. Once your file has been formally closed, a new submission will be required to open a new file.
- **Change Request Form:** Any changes or modifications (e.g. adding a Co-PI or a change in methodology) must be approved by the REB through the completion of a change request form before implemented.
- **Adverse or Unexpected Events Form:** Events must be reported to the REB within 72 hours after the event occurred with an indication of how these events affect (in the view of the Principal Investigator) the safety of the participants and the continuation of the protocol (i.e. un-anticipated or un-mitigated physical, social or psychological harm to a participant).
- **Research Project Completion Form:** This form must be completed when the research study is concluded.

Always quote your REB file number (15-102) on future correspondence. We wish you success with your study.

REB Chair
 Dr. Shirley Van Nuland
 shirley.vannuland@uoit.ca

Ethics and Compliance Officer
 researchethics@uoit.ca

NOTE: If you are a student researcher, your supervisor has been copied on this message.

13.12.2 Approval 2

Date: January 06, 2016
To: Lennart Nacke
From: Shirley Van Nuland, REB Chair
REB # & Title: (15-053) Gamification Application and User Study
Decision: APPROVED
Current Expiry: January 01, 2017

Notwithstanding this approval, you are required to obtain/submit, to UOIT's Research Ethics Board, any relevant approvals/permissions required, prior to commencement of this project.

The University of Ontario, Institute of Technology Research Ethics Board (REB) has reviewed and approved the research proposal cited above. This application has been reviewed to ensure compliance with the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS2 (2014)) and the UOIT Research Ethics Policy and Procedures. You are required to adhere to the protocol as last reviewed and approved by the REB.

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- **Research Project Completion Form:** This form must be completed when the research study is concluded.

Always quote your REB file number (15-053) on future correspondence. We wish you success with your study.

REB Chair
 Dr. Shirley Van Nuland
 shirley.vannuland@uoit.ca

Ethics and Compliance Officer
 compliance@uoit.ca

NOTE: If you are a student researcher, your supervisor has been copied on this message.

13.12.3 Approval 1 - Renewed

Date: March 26, 2017
To: Dennis Kappen
From: Janice Moseley, Research Ethics Coordinator
File # & Title: 13875 - (15-102) Survey Study for Gamified Physical Activity
Status: RENEWAL APPROVED
Current Expiry: April 01, 2018

The above-noted research ethics file has been renewed. You are required to continue to adhere to the protocol as last reviewed and approved by the Research Ethics Board (REB) at the University of Ontario Institute of Technology (UOIT).

This research is subject to continuing review requirements. This research file must be renewed or closed by the current expiry date (April 01, 2018) by using the following forms from the [IRIS research portal](#).

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Always quote your REB file number (**13875**) on future correspondence. We wish you continued success with your study.

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13.12.4 Approval 2 - Renewal

From: <researchethics@uoit.ca<mailto:researchethics@uoit.ca>>

Subject: REB Renewal Approved 15-053/13726

Date: January 2, 2017, at 08:40:45 EST

To: "Dr. Pejman Mirza-Babaei (Primary Investigator)" <pejman.mirza-babaei@uoit.ca<mailto:pejman.mirza-babaei@uoit.ca>>

Cc: <researchethics@uoit.ca<mailto:researchethics@uoit.ca>>

Date: January 02, 2017
To: Pejman Mirza-Babaei
From: Janice Moseley, Research Ethics Coordinator
Title: (15-053) Gamification Application and User Study
Status: RENEWAL APPROVED
Current Expiry: January 01, 2018

The above-noted research ethics file has been renewed. You are required to continue to adhere to the protocol as last reviewed and approved by the Research Ethics Board (REB) at the University of Ontario Institute of Technology (UOIT).

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13.13 License to Use Publications

13.13.1 Chapter 3: Theoretical Framework

Dennis L Kappen and Lennart E Nacke. 2013. The Kaleidoscope of Effective Gamification: Deconstructing Gamification in Business Applications. In *Proceedings of the First International Conference on Gameful Design, Research, and Applications - Gamification '13*, 119–122. <https://doi.org/10.1145/2583008.2583029>

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13.13.2 Chapter 5: Preliminary Studies

Dennis L. Kappen, Lennart E. Nacke, Kathrin M. Gerling, and Lia E. Tsotsos. 2016. Design Strategies for Gamified Physical Activity Applications for Older Adults. In *Proceedings of the Annual Hawaii International Conference on System Sciences-49*, 1309–18.
<https://doi.org/10.1109/HICSS.2016.166>



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Conference Proceedings: System Sciences (HICSS), 2016 49th Hawaii International Conference on

Author: Dennis L. Kappen

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13.13.3 Chapter 6: Survey Study

Dennis L Kappen, Pejman Mirza-Babaei, and Lennart E. Nacke. 2017. Gamification through the Application of Motivational Affordances for Physical Activity Technology. In *Proc. of CHIPLAY '17*, 5–18. <https://doi.org/10.1145/3116595.3116604>



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Title: Gamification through the Application of Motivational Affordances for Physical Activity Technology

Author: Dennis L. Kappen, et al

Publication: Proceedings

Publisher: Association for Computing Machinery, Inc.

Date: Oct 15, 2017

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13.13.4 Chapter 8: Experimental Study

Dennis L Kappen, Pejman Mirza-Babaei, and Lennart E. Nacke. 2018. Gamification of Older Adults' Physical Activity: An Eight-Week Study. In *Proceedings of the Annual Hawaii International Conference on System Sciences-51*.



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