

# **Development of a Constructivist Learning Environment on the Facial Expression Recognition Skills of Individuals with Autism Spectrum Disorder (ASD)**

by

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## **ABSTRACT AND KEWORDS**

This paper details the development of a prototype constructivist mobile application for individuals with Autism Spectrum Disorder (ASD), to aid them in identifying facial expressions in others. People with ASD have difficulty identifying facial expressions in others. The ability to recognize facial expressions is an important part of social competences which allow individuals to engage in social interactions, establish and maintain relationships, and get needs met. Many of the Facial Expression Recognition (FER) software which are commercially available are very prescriptive and allow for little or no input from their users. This app prototype that was developed and used in this study would enable users to set their learning goals, use photos of people they know, and set their own tests on that content. Ideally, participants who use this app would improve their FER skills and achieve their learning goals.

Keywords: Autism Spectrum Disorder, facial expressions recognition, mobile application, constructivism.

## **CHAPTER 1**

### **Introduction**

This paper describes a process for carrying out a pilot project for the development of a prototype constructivist mobile application (app) for use by individuals with Autism Spectrum Disorder (ASD).

ASD describes a range of developmental disabilities, including autism and pervasive developmental disorders, and is often characterized by impairments in social interaction and verbal and nonverbal communication (Baron-Cohen, 2004). ASD involves developmental differences in brain growth, organization, and function. It presents itself in a wide range of severities and features (Baron-Cohen, 2004).

It is estimated that ASD is found in 62 people in every 10,000 people within the general population (Elsabbagh et al., 2012). A characteristic of individuals with ASD is a difficulty identifying and interrupting facial expressions (American Psychological Association, 2000). The ability to discern emotion from facial expression recognition (FER) is an important aspect of successful social interaction (Leppänen & Nelson, 2006).

Many people with ASD have difficulties with social interaction, and specifically impairments in facial expression recognition (FER). The current Diagnostic and Statistical Manual of Mental Disorders diagnostic criteria for ASD include items related to deficits in identifying and processing emotion: “Marked impairments in the use of multiple nonverbal behaviors, such as...facial expression” (APA, 2000, doi:10.1176/appi.books.9780890425596.744053). However, some studies have shown that people with ASD can improve

their ability to identify facial expressions. However, the success of these efforts has varied considerably (Golan, Baron-Cohen, & Hill, 2006).

The majority of these FER methods relied heavily on prescribed techniques which allowed for little or no input from the people with ASD about the goals and directions of their efforts (Moore, McGrath, & Thorpe, 2000). The reason for this was due to two factors. First was that many forms of ASD are non-communicative, and feedback from those who are non-communicative is tremendously difficult. Second, the technology that allows users to change and adapt their software was unavailable (Moore, McGrath, & Thorpe, 2000).

Many studies have found that computer-assisted learning has advantages for people with ASD (Huntinger, 1996; Lahm, 1996; Moore, 1998). These studies suggest that if an app was developed that allowed the users to customize it, it might aid in improving FER skills in users who have ASD (Hmelo-Silver, Duncan, & Chinn, 2007; Guthrie et al., 2004; Kim, 2005). These studies assert that app users would be more engaged with the app if they were able to use the app for their learning purposes; users would be more persistent when undertaking tasks and tests, provided the users can determine the educational goals as opposed to the researchers or app developers. Hmelo-Silver, Duncan, and Chinn (2007) paraphrased a Confucian description of how people learn to explain the benefits of learner-centered education: “Tell me and I will forget; show me and I may remember; involve me and I will understand” (p.105).

Studies by Moore (1998) and Huntinger (1996) concurred with other researchers, and suggested it might be advantageous to develop a framework in which learners could have greater control over their learning environments and deal with materials which are not anonymous avatars. According to constructivist learning theory, people generate knowledge and meaning

from an interaction between their experiences and their ideas (Bednar, Cunningham, Duffy & Perry, 1992; Savery & Duffy, 1995). A model for designing constructivist learning environments (CLEs) that engage learners in meaning making based on constructivism was developed by American researchers, Duffy and Jonassen, 1992; Jonassen, 1991, 1995, 1996; Jonassen, Peck, and Wilson, 1998; Savery and Duffy, 1996.

Foremost among these developers and their CLE models was Jonassen's (1991) model that would allow learners to set their learning goals and "engage learners in active manipulative, complex, and authentic learning activities" (p. 4). The model asserted that Jonassen's CLE must be rooted in a problem or project (Duffy & Jonassen, 1992; Jonassen, 1991, 1995, 1996).

There were some studies and articles which offered rudimentary suggestions about how to incorporate constructivist principles into educational software, however, on closer examination, many were little more than helpful checklists which stood in stark contrast to the work of Jonassen and his associates. The Jonassen version of CLE provided a fulsome description of numerous aspects which would create a fully realized constructivist learning environment (Jonassen, Peck, & Wilson, 1998; Savery & Duffy, 1996).

For this study, a prototype app called Emotion Recognition (ER) was developed which conformed to Jonassen's CLE. ER will allow people with ASD to develop, test, and experiment with FER to improve their FER skills and confidence in their abilities. This outcome would provide some evidence that Jonassen's CLE is beneficial in creating effective educational software for people with ASD.

## **Statement of Problem**

The difficulty individuals with ASD experience in FER has far reaching consequences which are part of a broader lack of skills in social competence. Social competence is the ability, to engage in social interactions, establish and maintain relationships, and get needs met (Stichter, Randolph, Gage, & Schmidt, 2007). Over a longer term, social competence leads to increased self-esteem, self-confidence, and adaptability (Merrell & Gimpel, 1998).

Greater social competency decreases the likelihood of adverse treatment or victimization from others (Hall, 2009), whereas limited social competence may result in negative responses and judgments from others (Merrell & Gimpel, 1998), peer rejection, academic failure, and social dissatisfaction (Alwell & Cobb, 2009). The literature suggests that the ability to connect with others through sharing thoughts, ideas, and feelings is deeply satisfying for most people (Hourcade, Pilotte, West, & Parette, 2004).

A common characteristic of individuals with ASD is their lack of social competence (Koegel, Koegel, Hurley, & Frea, 1992; Roeyers, 1995). People with ASD have difficulty interpreting and predicting the emotions, intent, and beliefs of others, which leads to social, communication, and behavioural challenges (Baron-Cohen, Leslie, & Frith, 1985). These deficits in social skills could have long-term adverse effects, such as isolation (Rogers, 2000), difficulty maintaining employment (Cotugno, 2009), and a lack of outside interests (Eaves & Ho, 1997; Stichter et al., 2007).

As noted, the difficulty people with ASD experience in FER has far reaching consequences which are part of a broader lack of skills in social competence. It is important to keep in mind that people with ASD have difficulty in identifying complex emotions. Basic

emotions include six emotions: happiness, sadness, anger, fear, disgust, and surprise. These emotions are usually situation based (Ekman, 1993). Complex emotions are emotions that have a social element (Adolphs, 2002; Baron-Cohen, 2003). These emotions are culturally specific and rely on understanding the cultural and social context (Adolphs, 2002).

## **Background and Need**

More people are being identified as being on the Autism Spectrum now than in previous decades (Developmental, D. M. N. S. Y., 2014; Blumberg et.al. 2013). Many of these people are being identified in childhood. Teaching these children skills that neurotypical children often develop without explicit instruction is an important focus for both families and educators (Cumine, Leach, & Stevenson, 2000). Neurotypical is a term used to describe individuals who do not display any of the characteristics related to autism. One area of need is emotion recognition which allows for smooth social exchanges (Golan & Baron-Cohen, 2006b; Myles & Southwick, 2005). There is also evidence to suggest that those with ASD are vulnerable to depression and other mental illnesses. This highlights the need for interventions that can recognize the emotions of others (Hill, Berthoz, & Frith, 2001).

Importantly, generalizing these skills to other settings is vital, given that generalization of competencies is another identified challenge among individuals with ASD (Frith, 2003; Myles & Southwick, 2005; Simpson et al., 2008).

There are a few apps available in the marketplace that assert that they can teach FER skills to people with ASD. Upon closer examination, many of them used cartoon faces to demonstrate facial expressions, while other apps used photos of faces in extreme close-up,

without any context. None of them allowed for input from their users other than simple quiz functions.

Like many researchers, what drew me to this subject is rooted in a personal connection to autism. My older brother, Jack, was diagnosed with autism in his late twenties. He never finished high school, and his life was marred by repeated conflicts with authority and problems with substance abuse.

Brief interactions and exchanges with other people were baffling, sometimes explosive, but always unpredictable for Jack. If there was some way that he could have learned to manage this better, maybe things could have been different: fewer conflicts with authority, easier exchanges with the people who loved him. Perhaps, his life might have been better. Today, Jack lives on the street in Vancouver.

The ability to discern emotion from facial expressions is essential for successful social interaction (Leppänen & Nelson, 2006). FER is one facet of social competence. Social competence is the ability to engage in social interactions, establish and maintain relationships, and get needs met (Stichter, Randolph, Gage, & Schmidt, 2007). Over a longer term, social competence leads to increased self-esteem, self-confidence, and adaptability (Merrell & Gimpel, 1998).

This study would have dealt directly with the need of making these social interactions easier for people with ASD. Elliot and Gresham (1993) identified four factors that contribute to social skills deficits in people with ASD:

- 1) lack of knowledge,
- 2) lack of feedback and reinforcement,

- 3) lack of practice and opportunities, and
- 4) presence of interfering problem behaviours.

It may be advantageous when designing a computer-assisted FER application to bear these factors in mind and ensure that the application offers solutions to these factors. Several studies have focused on recognition by individuals with ASD of the six basic emotions: surprise, fear, disgust, sadness, anger, and happiness (Ekman, 1993; Ekman & Friesen, 1971). The findings have been inconclusive, with some studies suggesting that individuals with ASD are impaired in their ability to recognize emotional states of others (Braverman, Fein, Lucci, & Waterhouse, 1989; Celani, Battacchi, & Arcidiacono, 1999; Clark et al., 2008; Hobson, 1986; Loveland et al. 1995; Macdonald et al., 1989; Wallace, Coleman, & Bailey, 2008; Yirmiya et al., 1992).

However, other studies suggest that individuals with ASD perform no differently than neurotypical peers in their ability to recognize these basic emotions (Baron-Cohen, Spitz, & Cross, 1993; Gepner, Deruelle, & Grynfeltt, 2001; Grossman, Klin, Carter, & Volkmar, 2000; Jones, et al., 2011; Tracy, Robins, Schriber, & Solomon, 2011).

Studies examining the recognition of complex emotions, like embarrassment, friendliness, and jealousy, have found that individuals with ASD have greater difficulties than their neurotypical peers (Capps, Yirmiya & Sigman, 1992; Golan, Baron-Cohen, Hill, & Rutherford, 2007; Yirmiya et al., 1992).

Researchers have employed different techniques to aid individuals with ASD FER. These methods have included applied behaviour analysis (Grindle & Remington, 2005; Shaw, 2001; Stafford, 2000), social skills groups (Ryan & Charragain, 2010; Solomon, Goodlin-Jones, & Anders, 2004), direct instruction (Feng, Lo, Tsai, & Cartledge, 2008), and assistive technology

using virtual environments (Bölte et al., 2006; Golan & Baron-Cohen, 2006; Ryan & Charragain, 2010; Silver & Oakes, 2001; Swettenham, 1996; Tanaka et al., 2010). Conclusions from the research suggest that improving FER skills, using existing software, is possible, but that the results do not generalize to non-instructional contexts.

There appears to be a difference in results between studies which investigated basic emotions compared to those which looked into complex emotions in the literature. Basic emotions are happiness, sadness, anger, fear, disgust, and surprise.

Several studies support the use of computer interventions to aid in the development of FER skills for both basic and complex emotion recognition in individuals with ASD (Golan, Baron-Cohen, & Hill, 2006; Golan & Baron-Cohen, 2006; LaCava, Ranklin, Mahlios, Cook, & Simpson, 2010; LaCava, Golan, Baron-Cohen, & Smith- Myles, 2007; Silver & Oakes, 2001; Weinger & Depue, 2011). These computer interventions range from stand-alone software designed for use on desktop computers, to applications designed for iPads, to computer networks specifically designed for this research. Studies found computer-assisted learning has distinctive advantages for people with ASD (Huntinger, 1996; Lahm, 1996; Moore, 1998) since computers are predictable; they offer no social demands, they provide immediate feedback, and as often as one wishes.

## **Overview of paper**

In the next chapter, I will provide a literature review related to the development of the app, a theoretical framework, and a description of a pilot project for developing the app. In

chapter three, I will provide the methodology that could be used for such a pilot project. Chapter four describes the development of the app prototype, new research which has been published since the beginning of the project, and options for completing the app prototype.

## **CHAPTER 2 — Literature Review**

### *Introduction*

This chapter begins with a brief outline of ASD and then an overview of the conceptual framework which would provide a roadmap of how to develop and assess the application. Following this, there is an examination of social competence deficits in people with ASD. Then, the purposes of facial expressions and how they are processed by neurotypical people are discussed.

Critically, for this project, the differences between basic and complex emotions are explained. Subsequently, this chapter examines other studies regarding FER among people with ASD and, importantly, how the results of these studies can be categorized by studies based on basic and complex emotions. Then the use of FER software designed for people with autism is examined.

### *Autism*

In the early and mid-twentieth century ASD was considered a rare emotional disability of childhood caused by poor parenting. It was believed that the odd behaviours observed in these children were a result of an emotionally cold parent, usually the mothers. It was mistakenly believed that the mother was unable to bond with her child, and so the child developed ASD. Today, autism is considered to be a range of neurological disabilities with a variety of expressions.

The diagnosis of autism is reserved for individuals who meet criteria for the following three categories: communication impairments; social interaction impairments; and repetitive, stereotypic and restricted interests and activities. These behavioural patterns must be observed before three years old of age (APA, 2000). Kanner (1971) published the first study into autism. In this study, he described the significant characteristics of autism as intact rote memory, hypo- or hyper reactions to sensory input, resistance to change, reliance on strict routines, and an insistence on sameness (APA, 2000).

### *Conceptual Framework*

Social Cognitive Theory (SCT) posits that people learn by observing others in a variety of social settings (Bandura, 1986). An important concept of SCT is self-efficacy. According to Bandura (1986), “Self-efficacy is a person’s belief in their ability to accomplish tasks.” Self-efficacy is developed from experiences and self-perception. It can influence the outcome of events and represents an individual's perception of external social factors (Bandura, 1977; Mischel & Shoda, 1995). This theory postulates that learning occurs when individuals activate and sustain behaviours which attempt to attain an individual's goals. Learners can instigate new goals or modify existing goals at any time (Zimmerman, 1989).

Studies of SCT identify three subprocesses of learning: self-observation, self-judgment, and self-reaction (Bandura, 1986; Kanfer & Gaelick, 1986; Schunk, 1989). Individuals enter learning activities with goals such as acquiring knowledge or solving problems. Self-efficacy for goal attainment is influenced by innate abilities, prior experiences, attitudes toward learning, type of instruction, and the social context of the learning. As learners work on tasks, they should

be able to observe their performances, evaluate their progress, and change their goals or the way they work at any time. This evaluation of goal progress will enhance feelings of efficacy and goal attainment, and allows learners to set new and more challenging goals (Schunk, 1989).

The effects of goals on behaviour depend on three factors: difficulty level, specificity, and proximity (Bandura, 1986; Locke, Shaw, Saari, & Latham, 1981). An individual's goals that have specific performance standards are more likely than general tasks to increase the individual's learning and increase self-evaluations. People who are highly self-efficacious are more willing to participate in activities, and persist longer than those who doubt their capabilities (Bandura, 1986).

Individuals acquire information about their self-efficacy in a given domain from their performances, vicarious experiences, and forms of social persuasion. (Bandura, 1986). In appraising self-efficacy, individuals take into account such factors as perceived ability, expended effort, task difficulty, instructor assistance, and other factors which they believe may affect their success or failure. In designing the app, SCT provides a useful theoretical foundation to understand how goals set by learners allow them to create their knowledge and build greater self-efficacy.

Another theory that offers an explanation of learners' motivations and how to create more engaging learning environments is Self-Determination Theory (SDT). A central premise of SDT is that people have three needs that allow learning to happen. Those needs are autonomy, relatedness, and competence (Deci & Vansteenkiste, 2004).

However, some of the underlying assumptions of SDT are problematic when considering people with ASD. For instance, one of the tenets of SDT is that all individuals need approval

from peers, in some form, whereas one of the characteristics of ASD is the lack of concern about what other people think or feel.

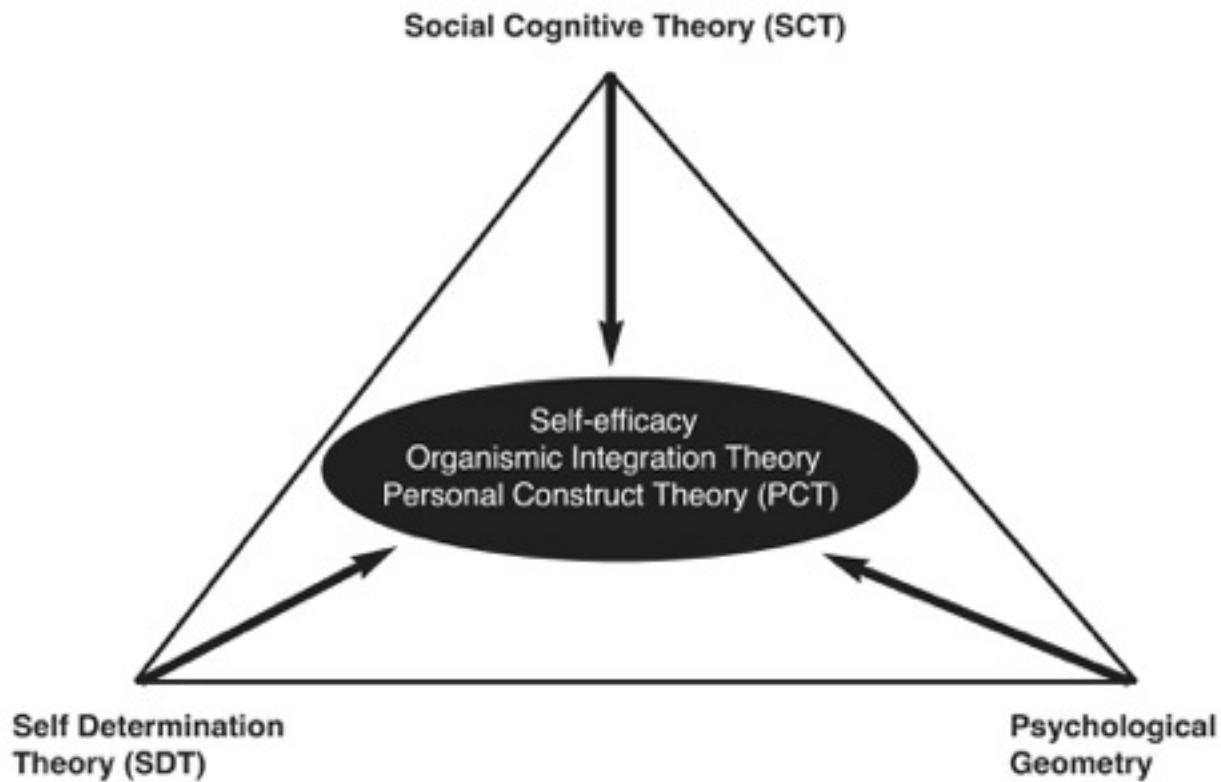
Another theory that would be useful in testing the efficacy of the app in a pilot trial derives from the work of George Kelly. His approach to psychotherapy was called Psychological Geometry (PG). According to PG, all people are “personal scientists” in anticipating the world (Kelly, 2003).

According to this theory, anticipation and prediction are the primary drivers of thought. Every person continually builds up and refines theories and models about how the world works so that they can anticipate events (Carver, Sutton, & Scheier, 2000).

Significantly, Kelley developed Personal Construct Theory (PCT) which offered a non-invasive approach to psychotherapy. Rather than having the therapist interpret a person’s psyche, the therapist should merely act as a facilitator of the patient finding their own constructs. To help the patient find their constructs, Kelly developed a method called the Repertory Grid Interview that aided patients in analyzing their *constructs* with little intervention or interpretation by the therapist (Kelly, 2003; Gaines & Shaw, 1993). In a pilot project, the repertory grid would allow the researcher to explore whether the app was beneficial to the participants in achieving their goals.

Below is a diagram illustrating the conceptual framework for this project. The three contributing theories to this study’s conceptual framework, SCT, SDT, and PG, form the theoretical parameters. Elements of each theory, self-efficacy, OIT, and PCT, which appear in the centre of the triangle, form the conceptual framework which offers a roadmap to answer the research questions. The diagram illustrates the theoretical parameters of the study and shows the

component parts of the contributing theories the researcher used in this project. The conceptual framework guides the development of the app, explains optimal learning environments, and ways in which learners can set their own goals and determine if they have achieved these goals.



**Figure 1 Conceptual Framework diagram.**

### Social competencies

People with ASD often experience difficulties with social interactions, including emotion recognition and reciprocity as well as nonverbal communication, like gestures, eye contact, and

facial expressions (APA, 2000; Baron-Cohen, 1995). The ability to recognize facial expressions is crucial to developing interpersonal connections. As well, FER aids in understanding the emotions and intentions of others, which is important in building social competencies (Rump, Giovannelli, Minshew, & Strauss, 2009).

The difficulty individuals with ASD experience with FER, particularly more complex emotions such as jealousy and embarrassment that require reflection (Bauminger, 2004; Capps, Yirmiya & Sigman, 1992) appear to impact negatively on their ability to make interpersonal connections.

Studies examining individuals with ASD FER abilities have revealed they focused on non-feature areas of the face significantly more often than core feature areas of the face (eyes, nose, and mouth). This is in contrast to neurotypical participants who focus on core features in face like the eyes, nose, and mouth. These findings were found in study participants as young as young as 15 months (Klin & Jones, 2008) as well as a high-functioning adolescent and adult males (Klin, Jones, Schultz, Volkmar, & Cohen, 2002; Pelphrey, Morris, & McCarthy, 2005; Rutherford, Clements, & Sekuler, 2007). According to Riby, Doherty-Sneddon, & Bruce (2009), people with ASD are less likely to process information from the eye region of the face (). An early indicator of ASD is reduced attention to faces and decreased eye contact (Osterling & Dawson, 1994). Individuals with ASD seem to process facial expressions in an atypical fashion with reduced attention to eyes and using piecemeal rather than wholistic strategies (Dawson, Webb, & McPartland, 2005).

FER is important because facial expressions provide clues to an individual's mental state. Inattention to facial expressions combined with a lack of social adaptation, may have a negative

impact on FER abilities (Behrmann, et al., 2006). These authors also suggest that face processing in individuals with ASD is underdeveloped because faces are both social and complex visual stimuli. As a result, FER is more than isolating and identifying specific facial features and their relationship to each other but requires a broader understanding of social contexts and norms.

FER allows individuals to check how others are reacting to them, estimate the effects of their social interactions, and inform them about external events (Sorce, Emde, Campos, & Klinnert, 1985). Beginning in infancy, neurotypical children reference a mother's emotional expression in determining their response (Klinnert, 1984; Sorce, Emde, Campos, & Klinnert, 1985). In contrast, children with ASD do not employ social referencing in similar situations, regardless of cognitive level (Bacon et al., 1998; Dawson et al., 2004).

### **Basic emotions compared to complex emotions**

Basic emotions include six emotions: happy, sad, anger, fear, disgust, and surprise. These emotions are usually situationally based. When a child was given a new toy, she smiled, and one would assume she was happy. A man's spouse died, and he cried; we believe he was sad. The expression of these emotions tends to be the same across different cultures (Ekman, 1993; Ekman & Friesen, 1971).

Complex emotions are those that have a social element (Adolphs, 2001; Baron-Cohen, 2003), meaning that these emotions only make sense when one understands the social context in which they occur, and involve understanding or predicting another's knowledge, beliefs, deceit, etc. Often, complex emotions are culturally specific and therefore rely on understanding the

cultural and social context (Adolphs, 2001) in which they occur. They include embarrassment, pride, jealousy, guilt, anxiety, insincerity, intimacy, and so on. In this way, to understand if someone is embarrassed, you would need to understand the situation that evokes this emotion. You would need to know what is expected, what occurred, and why someone would be embarrassed by such behaviour.

Overall, the research on FER for those with ASD is mixed. There is inconclusive research on individuals with ASD and performance on basic FER tasks, while other studies which focused on complex emotion recognition, found subjects had difficulties (Golan & Baron-Cohen, 2006). Existing research used various modalities and a range of ASD populations. It is important to note that the majority of these FER methods relied heavily on behaviourist educational techniques which allowed for little or no input from the people with ASD about the goals and directions of efforts (Moore, McGrath, & Thorpe, 2000).

For this project, it is important to distinguish between simple and complex emotional expressions as the complex emotions require an understanding of the social which generated them. Without knowing the specific social context, it is very difficult to interpret these expressions.

### *Basic Emotion Recognition*

When testing the FER of basic emotions, some studies have found those with ASD to perform without difficulty, and similarly to neurotypical peers (Adolphs, Sears, & Piven, 2001; Boucher, Lewis, & Collis, 2000; Castelli, 2005; Gepner, Deruelle, & Grynfeltt, 2001).

However, other researchers studying basic FER and ASD have come to opposite conclusions. Their evidence suggested that those with ASD performed different and worse than their neurotypical peers (Boraston, Blakemore, Chilvers, & Skuse, 2007; Bormann-Kischkel, Vilsmeier, & Baude, 1995; Celani, Battacchi, & Arcidiacono, 1999). These studies consisted of testing basic ER in the face and voice holistically, and matching different modalities (e.g., photos and videos), and using different populations (autistic, HFA, and AS).

### *Complex Emotion Recognition*

The findings related to complex emotion recognition FER are more conclusive than those found in basic emotion FER. Many studies found people with ASD have impairments in their FER skills when interrupting complex emotions. These include studies of the voice (Golan et al., 2007; Kleinmann, Marciano, & Ault, 2001; Rutherford, Baron-Cohen, & Wheelwright, 2002); face (Baron-Cohen, Wheelwright, Spong, Scabhill, & Lawson, 2001); and on measures of more subtle social cognition (Adolphs et al., 2002; Dziobek, Fleck, Kalbe, et al., 2006). Even children and adults with ASD, who performed as well as neurotypical peers in basic FER tasks, performed worse than neurotypical peers in complex FER and the ability to discern the mental state of others.

### **Computer interventions to aid individuals with ASD**

Several studies support the use of computer interventions to aid people with ASD to recognize both basic and complex emotions (Golan, Baron-Cohen, & Hill, 2006; Golan & Baron-Cohen,

2006; LaCava, Ranklin, Mahlios, Cook, & Simpson, 2010; LaCava, Golan, Baron-Cohen, & Smith- Myles, 2007; Silver & Oakes, 2001; Weinger & Depue, 2011). Several studies found computer-assisted instruction has distinctive advantages for people with ASD (Huntinger, 1996; Lahm, 1996; Moore, 1998). Computer instruction can deliver one-to-one instruction while being free from social demands such as appropriate eye contact. It also provides explicit rules, and immediate feedback with innumerable opportunities to practice (Huntinger, 1996; Lahm, 1996; Moore, 1998).

In light of the results of these studies, and the limitations identified by Moore (1998), Lahm (1996), and Huntinger (1996), it might be advantageous to look for a framework in which learners could have greater control over their learning environments, and deal with materials which are not anonymous avatars.

A meta-analysis was conducted by Jenks and Springer (2002) to determine the efficacy of computers-based inventions in efforts to improve FER skills among people with ASD. They reported that most of the literature purports a superiority of computers-based inventions over conventional instruction, but more research needs to be done to determine what makes computers-based inventions useful. The use of computer software for individuals with ASD has several advantages. It is predictable, consistent, and free from the social stress that people with ASD often find to be a burden (Gabriels & Hill, 2007).

There are some software packages available in the marketplace for people with ASD with the aim of improving FER skills. One of the most popular packages is Mind Reading (Baron-Cohen et al., 2001). It uses visual, contextual, and auditory information to assist individuals with ASD to improve emotion recognition and understanding of mental states. It is organized with a

taxonomy of 412 emotions and mental states grouped into 24 emotion groups and six developmental levels from age four to adulthood. (Gabriels & Hill, 2007). Mind Reading contains images of 2,472 faces, 2,472 voices, and 2,472 stories about emotions, resulting in 7,000 separate examples of emotions (Baron-Cohen, 2004). The software is not customizable by the user or available as an app for mobile devices.

One of the notable things about the literature on computer-based interventions was that there appeared to be only one study that used apps available on portable devices at this time. The balance of the studies used software designed for desktop computers. This was surprising as there are some factors which would make smartphones or tablets advantageous in these FER improvement efforts.

Foremost among these advantages is how smartphones are ubiquitous, especially in the age group which is the target population for this study. Smith's (2013) study found that 79% of all adults from ages 18 to 24 years had a smartphone, while 81% of adults 25-34 years old (Smith, 2013). The use of smartphones has only increased since that time of that study. Recently, Apple Corporation reported in a quarterly statement to shareholders that it had sold 75 million smartphones in North America from October to December of 2014 (Griswold, 2015). More people in Canada own smartphones than own desktop or laptop computers. It would follow that many people would be comfortable in the use of such devices (Andrus et al., 2011). As well, individuals with ASD have become accustomed to using smartphones and tablets for educational purposes as some educational apps have been developed and utilized in the Ontario secondary curriculum for students with ASD (Asuncion et al., 2012).

Smartphones and tablets can support multimedia software and would allow an app to utilize a variety of mediums, and enable the connectivity between a central processing engine and other users of the app (Herrington & Herrington, 2007).

Many studies have suggested that such characteristics as customizability, real-life contextualization, and user adaptability would improve FER outcomes for people with ASD when utilizing computer-assisted interventions (Moore, 1998; Huntinger, 1996; Ramdoss, Machalicek, Rispoli, Mulloy, Lang, & O'Reilly, 2012; Morris, Kirschbaum, & Pichard, 2010; Bernad-Ripoll, 2007; Tseng & Do, 2010; Davis, Dautenhahn, Nebaniv, & Powell, 2006; Heinmann, Nelson, Tjus, & Gillberg, 1995; Sehaba, Estrailleur, & Lambert, 2005). However, no study offered a comprehensive theory for a learning environment; most of the suggestions described elements found in constructivist learning theories.

## **Constructivism**

Constructivism is a learning theory that asserts learners learn by constructing understanding for themselves. Individuals conceive of external reality somewhat differently, based on the individual's unique experiences and beliefs (Bednar, Cunningham, Duffy, & Perry, 1992). In this way, the individual produces mental models or representations that explain what they have perceived (Jonassen, 1991).

These models are constantly changing because learning is an active process based on the learner's experience (Bednar, Cunningham, Duffy, & Perry, 1992). According to constructivist theory, "learning must be situated in a rich context, reflective of real world contexts" (Strijbos, Kirschner, & Martens, 2006).

## **Constructivist learning environments**

Jonassen (1991) proposed a model for designing constructivist learning environments (CLEs) that would engage learners in meaning making based on constructivist assumptions (Duffy & Jonassen, 1992; Jonassen, 1991, 1995, 1996; Jonassen, Peck, & Wilson, 1998; Savery & Duffy, 1996). According to Jonassen, the goal of a constructivist learning environments (CLEs) is to "engage learners in active, constructive, intentional, complex, authentic, cooperative, and reflective learning activities" (Jonassen, 1991, p.5). From this assumption, a model for designing CLEs should be rooted in a problem or project or question with related cases, information resources that support knowledge construction, cognitive tools, conversation and collaboration tools, and social-contextual support for implementation. These elements are supported by instructional supports, including modeling, coaching, and scaffolding (Jonassen, 1991, 1995, 1996; Jonassen, Peck, & Wilson, 1998; Savery & Duffy, 1996).

At the centre of Jonassen's CLE model is a problem, project, or question with interpretative and intellectual support systems around it. The learner's goal is to solve the problem, complete the project, answer the question, or resolve the issue. The learner is provided with related cases and information resources that support understanding of the problem and suggests possible solutions. There are tools that help the learner to interpret and manipulate aspects of the problems. There are conversation and collaboration tools that enable communities of learners to negotiate and co-construct meaning for the problem. And, there are social/contextual support systems help teachers implement the CLE (Jonassen, 1994).

This study used Jonassen's (1991) CLE model to design the app which would have been

employed in an intervention.

## Conclusion

This chapter started with a brief outline of ASD and then an overview of the conceptual framework which would provide a roadmap of how to develop and assess the application. The conceptual framework will aid in development of the app and allow the researcher to answer the question: Does the app assist people with ASD in reaching their self-formulated goals with respect to FER when used to help with social interactions and communication?

Following this, there was an examination of social competence deficits in people with ASD. Then, the purposes of facial expressions and how they are processed by neurotypical people were discussed. After which other studies regarding FER among people with ASD were examined and, importantly, how the results of these studies can be categorized by studies based on basic and complex emotions.

In the next chapter, the methodology that will be used in this study will be discussed. It begins with a description of the participants; how participants will be selected; and the settings involved. Next, is a description of the design of the study and the procedures that would have been followed by the investigator, including variables, instruments, and assessment. The chapter concludes with information about data analysis procedures, research hypotheses, and summary.

## **CHAPTER 3 - Method**

### **Introduction**

This chapter describes the methodology that will be used in this study. It begins with a description of the participants, how participants will be selected, and the settings involved. Next, is a description of the design of the study and the procedures that will be followed by the investigator, including variables, instruments, and assessment. The chapter concludes with information about data analysis procedures, research hypotheses, and summary.

### **Setting and Participants**

For the pilot, trial participants would be recruited for this study once permission to conduct research would be received from the University of Ontario Institute of Technology Research Ethics Board. Participants would be a sample of convenience. Ads would be placed in some ASD-related websites, as well as therapists who specialize in ASD will be approached to pass information about the study along to their clients. As well, autism researchers at the University of Western Ontario and McMaster University who are conducting long-term autism studies and operate their autism practice offered will be asked to circulate information about this study to their clients and study participants.

Potential participants would contact the investigator via email. The investigator would provide the potential participants with greater details about the trial. If these people were interested in participating in the study, the investigator would prescreen the potential participants according to the following criteria:

1. Participants would be considered potentially suitable for the study if they had an ASD diagnosis and IQ above 75 on a standardized intellectual measure. These criteria would ensure that they could read and navigate through the app.
2. Participants must be 18 years of age or older, as they are adults and can give consent to being part of the study.
3. They will need to have an iPhone 5 or greater and be proficient in its use, specifically the iPhoto, camera and download functions contained in these phones because the app will be designed for this platform as it is one of the common mobile devices available in the North American marketplace.

As well, these criteria match other studies seen in the literature review.

At least one neurotypical participant would be sought. This potential participant would be approached directly by the investigator. This inclusion of a non-ASD participant might provide insights how the app might improve and insure that the app can be used by everyone. Universal design is a design concept that accommodates the broadest possible spectrum of human ability in the design of all products and information systems. As well, the EILab is part of the Inclusive Design Institute and funding for the development of the app prototype might be extended as a consequence of this partnership.

The terms of the study, procedures and all consent information would be shared with participants at this point. Once participants have agreed to take part in the study, further specific details would be shared about technical requirements and where to download the app, and they would be asked to sign the consent forms.

Participants would be able to select the setting in which they would use the app. The mobile app could be used virtually anywhere. The investigator would suggest to participants that they use the app in a quiet area which allows them to concentrate on operating the software without distraction.

## **Intervention and Material**

For this study, a prototype of an app called Emotion Recognition (ER) will be developed to conform to Jonassen's description of a CLE. ER would allow people with ASD to develop, test, and experiment with facial expression recognition (FER). Users would be able to provide their photos, set their tests, and use the app for their purposes.

An important facet of the Jonassen CLE is that the problem should not be prescribed: "The problem should be ill-structured, so that elements of the problem are definable by the learners. Ill-structured problem has unstated goals and constraints. They have multiple solutions, solution paths, or no solutions at all" (Jonassen, 1994, p. 68).

The researcher will instruct the developer to incorporate five elements into the app:

1. A Noldus-based server that will be used to run the expression recognition algorithms. The app will connect to this server and use it for backend processing.
  
2. The app will allow users to access their pictures and send these pictures to the Noldus-based server for processing. As part of this second stage, there will be three sub-functions.
  - a) The user selects appropriate pictures.

- b) The system can detect facial shots automatically for sending these to Noldus server.
  - c) The system is also able to use the camera.
3. The last stage is the social aspect of the app in which users may communicate with each other.  
(Due to logistics around the prototype, this function will not be included in the prototype.)
4. The prototype would provide access to scaffolding around the use of the app through videos created by the researcher and made available on YouTube.
5. The prototype ER would afford users the opportunity to test their FER skills and examine aspects of facial expressions on different faces.

The prototype ER would have two modes. Mode one would allow users to test their FER abilities by accessing a database of facial expressions. This database called the Large MPI Facial Expression Database, was developed by researchers at the of the Brandenburg University of Technology and contains 55 facial expressions by 20 different people (Kaulard et. al., 2012). The 20 people represent a variety of ages, ethnic backgrounds, and both genders. The facial expressions are both simple and complex. All facial expressions are taken from three different angles with two emotional intensities. ER users could select specific faces to test themselves or particular emotions. Users could also select a random option in which the app would randomly select images from the database. Users could also browse the pictures in the MPI Facial Expression Database. See Figures 2, 3, and 4.

In the second mode, users could select images of people from their device. When selected, the images are sent to the FaceReader server in which they can be analyzed. Noldus Information Technology developed FaceReader, a system for fully automatic facial expression analysis. FaceReader recognizes facial expressions by distinguishing six basic emotions (happy,

angry, sad, surprised, scared, disgusted), and 26 complex emotions, with an accuracy of 89% (Loijens et. al., 2015).

The FaceReader server uses an algorithm to detect and isolate the faces of people found in the images sent to the server. Once identified, a second algorithm determines 500 key locations on the face. These 500 locations are then compared to a database of 10,000 faces which have been annotated by experts at Noldus (Loijens & Krips, 2015). Once the image is analyzed, it is deleted from the server and the emotional analysis tag is sent back to the user. In this mode, users could also use their photos to quiz themselves.

Users of ER could customize various aspects of the app, from content to functionality. In this way, users will be able to alter the app to meet their learning goals. The navigation of the app would be based on navigation of standard apps like sliding fingers across pictures to change images or dials to select answers.

## **Measurements Instruments**

Before and after the trial, participants would take a structured interview to gather data about their experience with the app and their confidence in their FER abilities. The study utilizes a repertory grid technique for this purpose.

The repertory grid is a structured interview method which identifies constructs in which people organize their world. The way in which we build these constructs is drawn from our experiences (Kelly, 2003).

The following steps will be taken to create and execute the rep repertory.

### *Step 1 - element elicitation*

The researcher will select a series of 15 elements related to FER skills and FER software.

The researcher will use the research question to guide this selection: Does the app assist people with ASD in reaching their self-formulated FER goals when used to help with social interactions and communication? Such elements might be about the participants' confidence in their FER skills or the usefulness, functionality, or adaptability of FER software. These descriptions will become elements which will frame the rep grid (Fransella, Bell, & Bannister, 2004).

### *Step 2- construct elicitation*

The researcher will interview the participants to elicit personal constructs about the elements selected in the first step. Utilizing a triadic elicitation method, the researcher would choose three of the elements from step 1. The researcher would then ask the participants “In what way are two of these similar to each other and the third one different?” The researcher will elicit as many constructs as possible. This should be repeated until no elements are left. The constructs generated here should be opposed (Fransella, Bell, & Bannister, 2004).

### *Step 3 - rating*

The constructs from step 2 would be used to rate the elements in a simple five-point Likert scale. The participants will assess the constructs in an online survey (Fransella, Bell, & Bannister, 2004).

#### *Step 4 - analysis*

The results of the surveys will be analyzed using an open source software package called OpenRepGrid. It was specifically designed for this type of analysis and offers a variety statistical procedures (Fransella, Bell, & Bannister, 2004; Muenchen, 2012).

#### **Procedure**

The study will involve the following steps and related activities:

- a) The University of Ontario Institute of Technology Review Ethics Board's forms needs to fill out and submitted. Approval for the study is required before recruitment of participants or data collection can take place.
- b) Solicit participants through ads placed on the Autism Ontario website and fliers distributed to therapists with ASD practices.
- c) Pre-screen applicants to ensure that they meet the criteria as described above.
- d) A signed consent form will need to be obtained from each participant after they have been given a complete understanding of the study's purpose either through emails or telephone meetings.
- e) Each participant will be interviewed to elicit constructs and elements as per the description of the rep grid process described above. The investigator will gather the results of the surveys taken by participants.
- f) The participants will be directed to the Apple app store to load the ER app.

- g) The initial training is made available on Youtube (video) and support. This would be a series of short videos using screenshots of the app and demonstrating its functions.
- h) Participants will be offered weekly assignments to help them become familiar with the app's functions. The app users are not required to complete the assignments.
  - a) Week 1 analyzes pictures in albums (simple emotions)
  - b) week 2 taking specific images (complex emotions)
  - c) week 3 customization of database
  - d) week 4 review of assignments and app functionality
- i) Data about the participants' use of the app will be collected during the intervention phase from the servers in the EI Lab.
- j) At the end of four weeks using the app, each participant was directed to take the rep grid structured interview method again. The investigator will gather the results of the study taken by participants.
- m) Statistical analysis of data will be completed.
- n) As a sign of appreciation, all participants who completed the trial will be given a \$50 Amazon gift certificates.

## **Research Hypotheses**

There will be differences from participants' pre- to post-intervention results on FER assessments on the rep grid interview method which is consistent with the project's theoretical

framework. Ideally, participants who used the ER app more often will have better results compared to participants who used the app less often. This would possibly indicate improved the FER skills of users due to the use of the app.

## Data Analysis

The researcher would require identifiers from the participants, including their names, phone numbers, email addresses, age, and gender. This information would be collected to gather demographic data and contact the participants. This information will be gathered and stored in an encrypted file on EI Lab servers.

All participants will be randomly assigned an identification number. For data analysis and information dissemination, only these figures will be employed (not the participants' names). All identifiable information being collected (e.g., name, phone number, etc.) will be kept separate from study data in a folder on the EILab server. All research data would have been kept for three year following the end of the study, for future analysis or re-analysis, at which point it will be destroyed.

The results of the rep grid survey will be analyzed by Web grid software at the UOIT EI Lab. Web grid utilizes a hierarchical cluster analysis. Typically, two-way clustering (co-clustering or bi-clustering) is done. Both elements and constructs are grouped and the sorted according to proximity. Then a dendrogram can be drawn using elements as the horizontal axis and constructs as the vertical axis. This diagram will indicate relationships between the elements and constructs (Shaw & Gaines, 2012).

For this study, the researcher would analyze the data from the rep grid to find answers to the following questions:

- a) Does the participant have a specific FER learning goal or goals?
- b) Did the app aid the participant in achieving this goal? (How effective or ineffective was the app in doing this?)

These questions are directly related to the conceptual framework. The adaptability and scaffolding of the app, using Jonassen's model, should give participants a sense of self-efficacy. If they have a sense of self-efficacy, it will allow the students to attain their learning goals.

The data would be analyzed in light of the participants's usage of the app as well. Ideally, greater usage of the app may lead to greater ease of attaining an individual's learning goals as was suggested by Jonassen (1991).

## **Limitations**

As with most educational research, the study has several limitations that frame may affect its results. These limitations consist of the sample, fidelity of the intervention, and instrumentation. Perhaps the most significant limitation would be the size of the study. The quantitative analysis would be confined to a convenience sample of voluntary participants. Therefore, the ability to generalize the results won't be possible.

While 20 hours of training were typically provided over a 10-15 week period in other similar studies, the current study would be conducted over a four week period, and training would be provided for 30 minutes, twice a week. It is possible that users would be more

comfortable with the app and its functionality if they would have more time to review the training videos and a longer time in the trial.

## **Summary**

This chapter described the methodology to be used in this study. It began with a description of the participants, how participants will be selected, and the settings involved. Then a description of the design of the survey and the procedures followed by the investigator, including variables, instruments, and assessment. The chapter concludes with information about data analysis procedures, research hypotheses, and summary.

The next chapter describes how this project may progress. The chapter begins with early stage development, the app coding, and the prototype could be made ready for trial. Then the chapter describes how research has continued since the start of this project and how resources related to app development both at Noldus and within the open source community have improved.

## **CHAPTER 4 —Project Progress**

### **Introduction**

This chapter describes how this project progressed. It will begin with early stage development, app coding, and the prototype app. Then the chapter describes how research has continued since the start of this project and how resources related to app development both at Noldus and within the open source community have improved.

### **Description of project progress**

#### *i. early stages (search for developer)*

The researcher and thesis supervisors worked out the parameters of the project and resources. Funds became available through the EILab at UOIT for the hiring of a coder to develop the ER app. For this study, an app called Emotion Recognition (ER) would be created, which conforms to Jonassen's vision of a CLE.

ER is different from other types of FER software for people with ASD because the users of ER software is different and would be able to alter the user interface while being able to add their own content to the app for FER analysis and testing.

The developer chosen needed to have experience in app development, database design, and have familiarity with iOS and Apache servers. As well, the developer would have to be able to liaise with Noldus developers as the facial recognition technology found in their FaceReader software would be used in the app. For the ER prototype, the version of the FaceReader was an API web version of FaceReader. Due to the proprietary

nature of this technology Noldus required all involved to sign non-disclosure agreements about their technology, and business practices.

As part of the non disclosure agreement with Noldus, only a UOIT student or grad could be utilized as a developer in this project. After nine months of searching and the aid of a faculty member in the computer science department, the researcher was able to find a graduate of the program who had FER software and database experience from her previous work.

### *ii. development of the app*

The developer was given three months to develop the app. However, there were difficulties in communications between the researcher and developer. Also, the complexity of the app increased as it had to run on three separate servers, a virtual Apache server at the EI Lab, another server in the lab, and a Windows server at Noldus. The combination of server upgrades and difficulties in communication due to misunderstandings between the developer and the researcher meant the app was delayed by two months. The developer produced a prototype of the app (See Appendix A for researcher's personal correspondence).

### *iii. working app (problems with app and servers and personal issues)*

The app was able to identify facial expressions from the database. However, only a limited number of photos could be uploaded to the app which could be analyzed by the Noldus FaceReader software (See Appendix B for researcher's personal correspondence).

There were some bugs which needed to be corrected to allow the app to be utilized in a trial. The bugs included that the interface was overly sensitive and difficult to navigate. When sliding the images on the screen or spinning a selection wheel, the pictures or wheel would move too fast, or images would slide quickly off the screen. As well, the app seemed to be only accessing a small portion of the database. Some of the on-screen text would have little meaning for a user. In this case, the button for the database was labeled “Noldus database” when it should be called “database”. And, in-app help and scaffolding needed to be added to make the app more user-friendly (See Appendix B for researcher’s personal correspondence).

However, the researcher experienced some personal problems which precluded him from continuing work on the study until fall, 2016. By that point, the developer was unable to continue work on the app due to other commitments. Using the research and existing prototype, the researcher developed the current project.

#### *iv. search for participants*

A key component of the trial would be finding participants who met the criteria described in the previous chapter. The researcher was able to establish contact with ASD researchers at the University of Western Ontario and McMaster University. They had dozens of clients and subjects which met the pilot study criteria. The researchers from Western and McMaster also offered to provide feedback about the app before being used in the trial.

#### *v. changing scope*

Once it was determined that the prototype app could not be altered and wouldn't be suitable for trial in its current state, the researcher switched from the Master of Arts program to the Master of Education program, and decided to engage in the current research as the culminating project.

## **Developments in the interim**

### *i. published articles*

Since the beginning of this study in 2014, research into FER technology and autism has continued apace. Some significant articles have been published in the last two years.

The first notable study was by a group of American researchers. In this study, researchers had 25 children and young adults with ASD use commercially available FER training programs. The study reported that after six weeks of use, the participants could more accurately and quickly identify feelings in facial expressions with stimuli from both the training tool and generalization measures and demonstrate improved self-expression of facial emotion. This reiterates the findings of some earlier studies e.g., (Russo-Ponsaran, et al. 2015).

Another important study recently published was by the British researchers Golan, Sinai-Gavrilov, and Baron-Cohen (2015). The researchers have refined and enlarged their FER test, the Cambridge Mindreading Face-Voice Battery (CAM II). In this study, they tested the new CAM II on 30 children aged 8 to 11 years. As with other studies they conducted, half of this group was diagnosed with ASD while the other half was neurotypical (Golan, Sinai-Gavrilov, & Baron-Cohen, 2015). The participants with ASD had lower scores than the neurotypical counterparts on complex ER from faces and voices. In particular, participants with ASD had difficulty with six

out of nine complex emotions. These results replicate similar studies that these researchers have conducted in the past (Golan, Sinai-Gavrilov, & Baron-Cohen, 2015).

In another study, a different set of researchers offered an unusual addition to the trial. The difficulties encountered by individuals with ASD when interacting with neurotypical (NT) individuals are often attributed to a failure in FER skills on the part of the people with ASD. It is also possible, however, that at least some of the difficulty is due to a failure of NT people's FER skills when interpreting the mental states of individuals with ASD. Previous research has frequently observed deficits in FER among individuals with ASD. Relatively little research has analyzed the ability of individuals with ASD to produce emotional facial expressions, and whether NT individuals can recognize expressions created by people with ASD (Brewer, et al. 2015).

This study examined NT and ASD participants' ability to recognize emotional expressions produced by either group (Brewer, et al. 2015). Results indicated that the expressions generated by those with ASD were less recognized by NT participants than expressions created by NT people and identified by participants with ASD. Interestingly, individuals with ASD could understand each other's expressions at a rate equal to or better than the NT recognized expressions within the NT group (Brewer, et al. 2015). The findings seem to support claims that ASD advocates have made in the past whereby they asserted that FER is a problem for NT people and not individuals with ASD.

Perhaps, the most interesting study, and the one that has a direct impact on this study, was suitably titled: "Wanting it Too Much: An Inverse Relation Between Social Motivation and Facial Emotion Recognition in Autism Spectrum Disorder" (Garman, et al. 2016). This study

examined social motivation and early-stage face perception as a way of understanding impairments in FER in a sample of youth with ASD. Early-stage face perception was recorded while participants completed a standardized FER task. Researchers obtained information about social motivation through interviews with participants' parents. According to these interviews, participants identified with greater motivation exhibited no better FER skills than those who were being identified as less motivated. These findings argue against theories which implied that social motivation was important to people with ASD (Garman, et al. 2016). The Garman study's findings may prove disadvantageous for the current pilot study, as it is hoped by this researcher that social motivation may be an incentive for people with ASD to find benefit in the app.

### *ii. Noldus developments*

In 2016, Noldus released FaceReader6, which offered some features and improvements which could be utilized by the ER app to enhance the user experience and improve its functionality. FaceReader 6 has an automatic analysis of six basic facial expressions, as well as neutral and now contempt. It can also indicate gaze direction, head orientation, and personal characteristics, such as age and gender. The software can perform immediate analysis of both video and still images.

FaceReader 6 has improved East-Asian FER, which had been problematic with previous versions of FaceReader. The new version also offered circumflex modeling which means the software can better recognize FER in photos of people whose faces are not looking directly at the camera.

### *iii. Open source code and interfaces*

In the last two years, some open source codes for FER software have become available, which include many of the functions that ER would have had. The open source codes have the added benefit that there are coding communities which continue to improve the codes and offer support to anyone wanting to utilize their work.

Out of the dozens of FER open codes available, the following three appear to be the most promising as they are the most similar to the ER app. One of the most promising FER open source codes is Facial Expression Recognition System-Matlab (FERSM) source code. According to tests of its algorithm, FERSM is more than 98% accurate in analyzing and correctly identifying basic emotional expressions. It also provides circumflex modelling. The code is available at [www.mathworks.com](http://www.mathworks.com) and [www.sourceforge.net](http://www.sourceforge.net).

Another promising open source FER code is Face Detect. It was originally released in 2012, but a major update of the code was released in 2016 which offered greater accuracy of FER. It is also available at [www.sourceforge.net](http://www.sourceforge.net).

The third promising open source FER code is OpenBR. It appears to have a remarkably robust and active support community. The software seems to have very high accuracy ratings. It is available for download at [www.openbiometrics.org](http://www.openbiometrics.org).

None of the preceding three open source codes offer any allowances for social collaboration or any interfaces. There are also some sources for free app interface software. One location called Open Grid Forum appears to have all the interface code for the database access, self-testing components, and user identity management functions needed for the ER app. There are thousands of codes related to app interfaces and a robust community supporting site and its

codes. It may be worth investigating open source resources which would significantly reduce the expense and time in the development of ER. The new developer would have to have experience in modifying code.

## **Summary**

This chapter described how the original thesis project progressed. It began with early stage development which was a prolonged search for an app developer within the UOIT community. Once a developer was located, she produced a prototype but was unable to complete the work on the app any further due to other commitments. Towards the end of the chapter, new research in the ASD FER technology field was discussed and how it affirmed much of what was previously known and how that impacts this study. Finally, the chapter recounts how technical resources, both proprietary and open source have become available or improved in the last two years.

In the next chapter, the researcher offers a personal reflection on the project so far and recommendations on how it should progress from this point.

## **CHAPTER 5 — Reflection**

### **Introduction**

This chapter is a personal reflection of this project from inception to the present. The researcher offers recommendations about how the app could be made ready for trial. And, finally, reflects on the benefits of the project and how it might be continued in the future.

### **Inception**

As I mentioned earlier in this paper, what drew me to this subject is rooted in a personal connection to autism. My older brother, Jack, was diagnosed with autism in his late twenties. He never finished high school, and his life was marred by repeated conflicts with authority and problems with substance abuse. We attended a small elementary school in rural Ontario. It was strict and had few resources. Jack had a tough time in school. Ultimately, Jack graduated from the school embittered by its rules and stringency.

Ironically, Jack was always a stickler for rules, but if he felt a rule or a law was unfair somehow or was formulated by someone he didn't consider intelligent, he believed he could ignore that rule or law. Compounding this belief was the fact that he had a streak of radical libertarianism in him, whereby he felt he was equal to authority figures. In fact, most authority figures, especially in small communities, depend heavily on being in a position of superiority. Jack seemed to exist in a constant aggrieved egalitarian state. At the same time, he had difficulty interpreting the moods of others and their intentions in their social interactions with him. These three characteristics seemed to ensure that Jack would have a difficult life.

In many ways, the small interactions and exchanges between people form the fabric of our lives. This is the texture of our existence. For Jack, these transactions and interactions are baffling, sometimes explosive, but always unpredictable. If there was some way he could have learned to manage this better and maybe things could have been different; fewer conflicts with authority, easier exchanges with the people who loved him. Perhaps, his life might have been better. Today, Jack lives on the street in Vancouver.

Jack is often on my mind. I think about how my life could have easily mirrored his; how we are different and how we are similar. My mind is often filled with melancholy and regret when I think about him.

While taking the class, Advanced Research Methods (ARM), the students were charged with developing a research proposal. At about the same time I had happened across a few apps in the Apple app store which purported to teach children with ASD FER. I was attracted by the claims of these apps. However, when I looked at the apps in more detail, I found them sadly lacking. Many of them used cartoon faces to demonstrate facial expressions, while other apps used photos of faces, in extreme close-up, without any context. The apps seemed to be produced without the input of users and, there was no way for the users to modify the apps. They appeared to be running counter to the way in which so many developers were creating apps which were customizable by their users. I wondered what Jack would have thought of these apps.

For the ARM project, I offered an idea which would improve on these apps by making them adaptable to users and useful to people like Jack. The assignment led to other assignments which allowed me to continue researching this idea.

After completing ARM and discussing my ideas with Dr. vanOostveen, I decided to

pursue a Master of Arts degree and utilize my ARM project as the basis for my thesis. Dr. van Oostveen was enthusiastic about the project and offered the aid of the EILab and funding for the project.

## **Literature review**

I started my literature review by using research portals available through the UOIT library. I organized my findings in an annotated bibliography. Through this process, it became apparent that the literature could be divided into two groups.

The first and certainly largest group included articles, reports, and dissertations which were written by researchers from either medical or psychological disciplines. Broadly, these researchers approached FER from a behaviouristic perspective. The trials appeared to be trying to emulate the physical sciences by refusing to speculate about the participants' experience. Also, the research seemed to be dominated by the researchers. The researchers were the sole arbitrators of success and failure with no input from their studies' participants.

The second group included articles, reports, and dissertations which were written by researchers from the educational discipline. Many of them discussed the benefits of constructivism and the importance of learners constructing their knowledge. However, most of these articles and dissertations then used behaviourist methods like the disappointing apps mentioned above.

It also became apparent that studying facial expressions allowed people with ASD to improve their FER skills as determined by the researchers. But was it successful according to the participants? No one seemed to know. In most cases, it seems that the researchers never asked.

## **Method**

The method appeared to be simple enough from the beginning. Develop the app, recruit participants, test them before they use the app and after they used the app.

After reviewing the literature, it seemed that I would have to administer the Cambridge Mindreading Face-Voice Battery test as the pre and post-test for my trial. This test was designed to evaluate emotion recognition among adults with Asperger's syndrome. It comprises 54 video clips of facial expressions and 54 audio clips of emotional voices. (Golan, Baron-Cohen, & Hill, 2006). This test seemed to be the gold standard for many researchers in the ASD/FER field. However, the Cambridge test never really felt like a good fit with my constructivist predilections. It seemed terribly authoritarian with its roots firmly planted in a behaviourist tradition.

At this point, Dr. van Oostveen suggested I look at the work of George Kelly. Kelly developed a process called the repertory grid. It is an instrument designed to capture a person's personal meaning about a given subject. It is a structured interview designed to make those constructs with which individuals organize their world (Kelly, 2003). This allayed my concerns and ensured that participants would be able to set their own goals when using the app, while the rep grid method would be used to reveal the personal meanings users might derive from the entire exercise.

## **App development**

The app development was the most frustrating part of this project for me. Finding a developer was daunting, , and, according to a non-disclosure agreement with Noldus, only a

student or faculty member at UOIT could be hired for this task. No faculty member was available to help with development of the prototype.

After more than nine months, we found a recent graduate from the computer science program who had FER software and database experience from her previous work. There were many communication problems between the developer and me, but the developer was paid and produced a prototype of the app. The app worked at a basic level, but there were bugs to be worked out, and changes needed to be made to the interface.

Due to family problems, I was unable to work on the project for a few months. When I was able to return to the project, the developer was unable and unwilling to work on the app. There was no one available to complete the app.

At this point, I had to return to the masters of education program, take a few classes and complete a final project. I was very disappointed by this. I had been working for nearly two years to create this app and test it.

## **Recommendations**

Unfortunately, the developer could no longer work on the app due to other commitments, and we were unable to make the prototype ready for a trial. If we could have hired a developer outside of UOIT, we might have been able to find one who could see the project through to the end. Another option is to use open source coding which wouldn't require all of the skills the first developer needed. As well, the communication difficulties with the first developer underscored the importance of having smooth communication exchanges and being able to convey

expectations with everyone involved in the project. It seemed ironic that one of my greatest frustrations were communication problems between myself and the developer while creating an app that would aid the communication skills of people with ASD.

Instead of building the app from scratch, we could use open source code. There are robust communities around these codes which could be employed to create ER. Some researchers in the U.S. and the U.K. have built similar types of software in this fashion. Usually, they have been able to develop their software for a few thousand dollars.

Working with the researchers at Western and McMaster, I may have been able to find not only participants but also possibly could have made valuable connections for publication. Those researchers could also provide valuable feedback about the functionality of the app as well.

## **Conclusions**

To say the least, I was disappointed we were not able to get the prototype ready for trial. However, I think the project is workable and would be an excellent doctoral thesis. In this way, it provides me with a wonderfully detailed blueprint for that work.

I hope that if I had been able to complete the study, it would have provided some useful insights into constructivist educational theory related to people who have been diagnosed with ASD. And, ideally, the participants would have benefited from the app in what they were trying to achieve through this tool.

## REFERENCES

- Adolphs, R. (2002). Neural systems for recognizing emotion. *Current opinion in neurobiology*, 12(2), 169-177.
- Adolphs, R., Sears, L., & Piven, J. (2001). Abnormal processing of social information from faces in autism. *Journal of cognitive neuroscience*, 13(2), 232-240.
- Alwell, M. & Cobb, B. (2009). Social and communicative interventions and transition outcomes for youth with disabilities: A systematic review. *Career Development for Exceptional Individuals*, 32(2), 94-107.
- American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., Text Revised). Washington, DC: Author.
- Andrus, J., Dall, C., Hof, A. V. T., Laadan, O., & Nieh, J. (2011). Cells: a virtual mobile smartphone architecture. In *Proceedings of the Twenty-Third ACM Symposium on Operating Systems Principles* (pp. 173-187). ACM.
- Asuncion, J. V., Budd, J., Fichten, C. S., Nguyen, M. N., Barile, M., & Amsel, R. (2012). Social media use by students with disabilities. *Academic Exchange Quarterly*, 16(1), 30-35.
- Bacon, A. L., Fein, D., Morris, R., Waterhouse, L., & Allen, D. (1998). The responses of autistic children to the distress of others. *Journal of autism and developmental disorders*, 28(2), 129-142.
- Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Prentice-Hall, Inc.
- Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological review*, 84(2), 191.

Baron-Cohen, S. (1995). *Mindblindness: An Essay on Autism and Theory of Mind*. Cambridge, MA: MIT Press/Bradford Brooks.

Baron-Cohen, S. (2003). *The essential difference: Men, women and the extreme male brain*. London: Penguin.

Baron-Cohen, S. (2004). *Mind Reading Emotions Library: The Interactive Guide to Emotions (CD-ROM)*. London: Jessica Kingsley Publishers Ltd.

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a ‘theory of mind’?. *Cognition*, 21(1), 37-46.

Baron-Cohen, S., Spitz, A., & Cross, P. (1993). Can children with autism recognize surprise? A research note. *Cognition and Emotion*, 7(6), 507-516.

Baron-Cohen, S., Wheelwright, S., Spong, A., Scahill, V., & Lawson, J. (2001). Are intuitive physics and intuitive psychology independent? A test with children with Asperger Syndrome. *Journal of Developmental and Learning Disorders*, 5(1), 47-78.

Bauminger, N. (2004). Brief report: Individual social-multi-modal intervention for HFASD. *Journal of autism and developmental disorders*, 37(8), 1593-1604.

Bednar, A. K., Cunningham, D., Duffy, T. M., & Perry, J. D. (1992). Theory into practice: How do we link. *Constructivism and the technology of instruction: A conversation*, 17-34.

Behrmann, M., Avidan, G., Leonard, G., Kimchi, R., Luna, B., Humphreys, K., & Minshew, N. (2006). Configural processing in autism and its relationship to face processing. *Neuropsychologia*, 44(1), 110-129.

Bernad-Ripoll, S. (2007). Using a self-as-model video combined with Social Stories™ to help a child with Asperger syndrome understand emotions. *Focus on Autism and Other Developmental Disabilities*, 22(2), 100.

Blumberg, S. J., Bramlett, M. D., Kogan, M. D., Schieve, L. A., Jones, J. R., & Lu, M. C. (2013). Changes in prevalence of parent-reported autism spectrum disorder in school-aged US children: 2007 to 2011–2012. *National health statistics reports*, 65(20), 1-7.

Bölte, S., Hubl, D., Feineis-Matthews, S., Prvulovic, D., Dierks, T., & Poustka, F. (2006). Facial affect recognition training in autism: Can we animate the fusiform gyrus? *Behavioral Neuroscience*, 120(1), 211-216.

Boraston, Z., Blakemore, S. J., Chilvers, R., & Skuse, D. (2007). Impaired sadness recognition is linked to social interaction deficit in autism. *Neuropsychologia*, 45(7), 1501-1510.

Bormann-Kischkel, C., Vilsmeier, M., & Baude, B. (1995). The development of emotional concepts in autism. *Journal of Child Psychology and Psychiatry*, 36(7), 1243-1259.

Boucher, J., Lewis, V., & Collis, G. M. (2000). Voice processing abilities in children with autism, children with specific language impairments, and young typically developing children. *Journal of Child Psychology and Psychiatry*, 41(7), 847-857.

Braverman, M., Fein, D., Lucci, D., & Waterhouse, L. (1989). Affect comprehension in children with pervasive developmental disorders. *Journal of Autism and Developmental Disorders*, 19(2), 301-316.

Brewer, R., Biotti, F., Catmur, C., Press, C., Happé, F., Cook, R., & Bird, G. (2015). Can neurotypical individuals read autistic facial expressions? Atypical production of emotional facial expressions in Autism Spectrum Disorders. *Autism Research*.

- Capps, L., Yirmiya, N., & Sigman, M. (1992). Understanding of simple and complex emotions in non-retarded children with autism. *Journal of Child Psychology and Psychiatry*, 33(7), 1169-1182.
- Carver, C. S., Sutton, S. K., & Scheier, M. F. (2000). Action, emotion, and personality: Emerging conceptual integration. *Personality and social psychology bulletin*, 26(6), 741-751.
- Castelli, F. (2005). Understanding emotions from standardized facial expressions in autism and normal development. *Autism*, 9(4), 428-449.
- Celani, G., Battacchi, M., & Arcidiacono, L. (1999). The understanding of the emotional meaning of facial expressions in people with autism. *Journal of Autism and Developmental Disorders*, 29(1), 57-66.
- Clark, T. F., Winkielman, P., & McIntosh, D. N. (2008). Autism and the extraction of emotion from briefly presented facial expressions: Stumbling at the first step of empathy. *Emotion*, 8(6), 803-809.
- Cotugno, A. J. (2009). Social competence and social skills training and intervention for children with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, 39(9), 1268-1277.
- Cumine, V. (2000). Leach, J. and Stevenson. G. (1998) *Asperger Syndrome: A Practical Guide for Teachers*.
- Davis, M., Dautenhahn, K., Nehaniv, C., & Powell, S. (2006). Touchstory: Towards an interactive learning environment for helping children with autism to understand narrative. *Computers Helping People with Special Needs*, 785-792.

Dawson, G., Toth, K., Abbott, R., Osterling, J., Munson, J., Estes, A., & Liaw, J. (2004). Early social attention impairments in autism: social orienting, joint attention, and attention to distress. *Developmental psychology, 40*(2), 271.

Dawson, G., Webb, S. J., & McPartland, J. (2005). Understanding the nature of face processing impairment in autism: insights from behavioral and electrophysiological studies. *Developmental neuropsychology, 27*(3), 403-424.

Deci, E. L., & Vansteenkiste, M. (2004). Self-determination theory and basic need satisfaction: Understanding human development in positive psychology. *Ricerche di Psicologia.*

Developmental, D. M. N. S. Y., & 2010 Principal Investigators. (2014). Prevalence of autism spectrum disorder among children aged 8 years-autism and developmental disabilities monitoring network, 11 sites, United States, 2010. *Morbidity and mortality weekly report. Surveillance summaries (Washington, DC: 2002), 63*(2), 1.

Duffy, T. M., & Jonassen, D. H. (Eds.). (1992). Constructivism and the technology of instruction: A conversation. Psychology Press.

Dziobek, I., Fleck, S., Kalbe, E., Rogers, K., Hassenstab, J., Brand, M., & Convit, A. (2006). Introducing MASC: a movie for the assessment of social cognition. *Journal of autism and developmental disorders, 36*(5), 623-636.

Eaves, L. C., & Ho, H. H. (1997). School placement and academic achievement in children with autistic spectrum disorders. *Journal of Developmental and Physical Disabilities, 9*(4), 277-291.

Ekman, P. (1993). Facial expression and emotion. *American Psychologist, 48*(4), 384-392.

Ekman, P., & Friesen, W. V. (1971). Constants across cultures in the face and emotion. *Journal of*

*Personality and Social Psychology, 17(2),* 124-129.

Elliot, S.N., & Gresham, F.M. (1993). Social skills interventions for children. *Behavior Modification, 17(3),* 287-313.

Elsabbagh, M., Divan, G., Koh, Y. J., Kim, Y. S., Kauchali, S., Marcín, C., & Fombonne, E. (2012). Global prevalence of autism and other pervasive developmental disorders. *Autism Research, 5(3),* 160-179.

Feng, H., Lo, Y., Tsai, S., & Cartledge, G. (2008). The effects of theory of mind and social skill training on the social competence of a sixth-grade student with autism. *Journal of Positive Behavior Interventions, 10(4),* 228-242.

Fransella, F., Bell, R., & Bannister, D. (2004). *A manual for repertory grid technique.* John Wiley & Sons.

Frith, U. (2003). *Autism: Explaining the enigma* (2nd ed.). New York: Blackwell Pub.

Gabriels, R. L., & Hill, D. E. (Eds.). (2007). *Growing up with autism: Working with school-age children and adolescents.* Guilford Press.

Gaines, B. R., & Shaw, M. L. (1993). Knowledge acquisition tools based on personal construct psychology. *The knowledge engineering review, 8(01),* 49-85.

Garman, H. D., Spaulding, C. J., Webb, S. J., Mikami, A. Y., Morris, J. P., & Lerner, M. D. (2016). Wanting it Too Much: An Inverse Relation Between Social Motivation and Facial Emotion Recognition in Autism Spectrum Disorder. *Child Psychiatry & Human Development, 1-13.*

- Gepner, B., Deruelle, C., & Grynfeltt, S. (2001). Motion and emotion: A novel approach to the study of face processing by young autistic children. *Journal of Autism and Developmental Disorders*, 31(1), 37-45.
- Golan, O., & Baron-Cohen, S. (2006). Systemizing empathy: Teaching adults with Asperger syndrome or high-functioning autism to recognize complex emotions using interactive multimedia. *Development and Psychopathology*, 18(2), 591-617.
- Golan, O., Baron-Cohen, S., & Hill, J. (2006). The Cambridge Mindreading (CAM) Face-Voice Battery: Testing Complex Emotion Recognition in Adults with and without Asperger Syndrome. *Journal of Autism and Developmental Disorders*, 36(2), 169-183.
- Golan, O., Baron-Cohen, S., Hill, J. J., & Rutherford, M. D. (2007). The 'Reading the Mind in the Voice' Test-Revised: A study of complex emotion recognition in adults with and without autism spectrum conditions. *Journal of Autism and Developmental Disorders*, 37(6), 1096-1106.
- Golan, O., Sinai-Gavrilov, Y., & Baron-Cohen, S. (2015). The Cambridge Mindreading Face-Voice Battery for Children (CAM-C): complex emotion recognition in children with and without autism spectrum conditions. *Molecular autism*, 6(1), 1.
- Grindle, C. F., & Remington, B. (2005). Teaching Children with Autism when Reward is Delayed. The Effects of Two Kinds of Marking Stimuli. *Journal of Autism and Developmental Disorders*, 35(6), 839-850.
- Griswold, A. (2015). The iPhone 6 Just Shattered Apple's Own Sales Records. *slate.com*. Retrieved from [http://www.slate.com/blogs/moneybox/2015/01/27/iphone\\_6\\_shatters\\_sales\\_records\\_apple\\_has\\_a\\_great\\_first\\_quarter\\_in\\_2015.html](http://www.slate.com/blogs/moneybox/2015/01/27/iphone_6_shatters_sales_records_apple_has_a_great_first_quarter_in_2015.html)

- Grossman, J. B., Klin, A., Carter, A. S., & Volkmar, F. R. (2000). Verbal bias in recognition of facial emotions in children with Asperger syndrome. *Journal of Child Psychology and Psychiatry*, 41(3), 369-379.
- Guthrie, J. T., Wigfield, A., Barbosa, P., Perencevich, K. C., Taboada, A., Davis, M. H., & Tonks, S. (2004). Increasing Reading Comprehension and Engagement Through Concept-Oriented Reading Instruction. *Journal of Educational Psychology*, 96(3), 403.
- Hall, L.J. (2009). *Autism Spectrum Disorders: From theory to practice*. Upper Saddle River, NJ: Pearson Merrill
- Heimann, M., Nelson, K. E., Tjus, T., & Gillberg, C. (1995). Increasing reading and communication skills in children with autism through an interactive multimedia computer program. *Journal of autism and developmental disorders*, 25(5), 459-480.
- Herrington, A., & Herrington, J. (2007). Authentic mobile learning in higher education.
- Hill, E., Berthoz, S., & Frith, U. (2001). Brief report: Cognitive processing of own emotions in individuals with autistic spectrum disorder and in their relatives. *Journal of Autism and Developmental Disorders*, 34, 229-235.
- Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist*, 42(2), 99-107.
- Hobson, R. (1986). The autistic child's appraisal of expressions of emotion: A further study. *Journal of Child Psychology and Psychiatry*, 27(5), 671-680.
- Hourcade, J., Pilotte, T., West, E., & Parette, P. (2004). A History of Augmentative and Alternative Communication for Individuals with Severe and Profound Disabilities. *Focus*

*on Autism and Other Developmental Disabilities*, 19(4), 235-244.

Huntinger, P. L. (1996). Computer applications in programs for young children with disabilities:

Recurring themes. *Focus on Autism and Other Developmental Disabilities*, 11, 105-14.

Jenks, M. & Springer, J. (2002). A view of the research on the efficacy of CAI. *Electronic*

*Journal for the Integration of Technology in Education*, 1 (2), p. 43-58.

Jonassen, D. H. (1991). Objectivism versus constructivism: Do we need a new philosophical

paradigm? *Educational technology research and development*, 39(3), 5-14.

Jonassen, D. H. (1994). Thinking Technology: Toward a Constructivist Design Model.

*Educational technology*, 34(4), 34-37.

Jonassen, D.H. (1995). An instructional design model for designing constructivist learning

environments. In H. Maurer (Ed.), *Proceedings of the World Conference on Educational*

*Media*. Charlottesville, VA: AACE.

Jonassen, D.H. (1996). Computers in the classroom: Mindtools for critical thinking. Columbus,

OH: Prentice-Hall.

Jonassen, D.H., Peck, K., & Wilson, B.G. (1998) Learning with Technology: A constructivist

perspective. Columbus, OH: Merrill/Prentice-Hall.

Jones, C. G., Pickles, A., Falcaro, M., Marsden, A. S., Happé, F., Scott, S. K., & Charman, T.

(2011). A multimodal approach to emotion recognition ability in autism spectrum

disorders. *Journal of Child Psychology and Psychiatry*, 52(3), 275-285.

Kanfer, F. H. & Gaelick, L. (1986). Self-management methods. In F. H. Kanfer & A. P. Goldstein

(Eds.). *Helping people change: A textbook of methods* (3rd ed.). Elmsford, NY: Pergamon

Press.

- Kanner, L. (1971). Follow-up study of eleven autistic children originally reported in 1943. *Journal of autism and childhood schizophrenia*, 1(2), 119-145.
- Kaulard, K., Cunningham, D. W., Bühlhoff, H. H., & Wallraven, C. (2012). The MPI facial expression database—a validated database of emotional and conversational facial expressions. *PloS one*, 7(3), e32321.
- Kelly, G. A. (2003). A brief introduction to personal construct theory.
- Kelley, H. H. (1973). The processes of causal attribution. *American psychologist*, 28(2), 107.
- Kim, J. S. (2005). The effects of a constructivist teaching approach on student academic achievement, self-concept, and learning strategies. *Asia Pacific Education Review*, 6(1), 7-19.
- Kleinman, J., Marciano, P. L., & Ault, R. L. (2001). Advanced theory of mind in high-functioning adults with autism. *Journal of autism and developmental disorders*, 31(1), 29-36.
- Klin, A., & Jones, W. (2008). Altered face scanning and impaired recognition of biological motion in a 15-month-old infant with autism. *Developmental science*, 11(1), 40-46.
- Klin, A., Jones, W., Schultz, R., Volkmar, F., & Cohen, D. (2002). Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of general psychiatry*, 59(9), 809-816.
- Klinnert, M. D. (1984). The regulation of infant behavior by maternal facial expression. *Infant Behavior and Development*, 7(4), 447-465.
- Koegel, L. K., Koegel, R. L., Hurley, C., & Frea, W. D. (1992). Improving social skills and disruptive behavior in children with autism through self-management. *Journal of Applied*

*Behavior Analysis*, 25(2), 341-353.

LaCava, P. G., Golan, O., Baron-Cohen, S., & Myles, B. (2007). Using assistive technology to teach emotion recognition to students with Asperger syndrome: A Pilot Study. *Remedial and Special Education*, 28(3), 174-181.

LaCava, P. G., Rankin, A., Mahlios, E., Cook, K., & Simpson, R. L. (2010). A single case design evaluation of a software and tutor intervention addressing emotion recognition and social interaction in four boys with ASD. *Autism*, 14(3), 161-178.

Lahm, E. A. (1996). Software that engages young children with disabilities: A study of design features. *Focus on Autism and other Developmental Disabilities*, 11, 115–24.

Leppänen, J. M., & Nelson, C. A. (2006). The development and neural bases of facial emotion recognition. *Advances in child development and behavior*, 34, 207-246.

Locke, E. A., Shaw, K. N., Saari, L. M., & Latham, G. P. (1981). Goal setting and task performance: 1969–1980. *Psychological bulletin*, 90(1), 125.

Loijens, Leanne; Krips, Olga; van Kuilenburg, Hans; den Uyl, Marten; & Ivan , Paul (2015) FaceReader 6.1 Reference Manual. Wageningen, Netherlands: Noldus Information Technology.

Loijens, Leanne & Krips, Olga (2015) Noldus FaceReader Methodology Note. Wageningen, Netherlands: Noldus Information Technology.

Loveland, K. A., Tunali-Kotoski, B., Chen, R., & Brelsford, K. A. (1995). Intermodal perception of affect in persons with autism or Down syndrome. *Development and Psychopathology*, 7(3), 409-418.

Macdonald, H., Rutter, M., Howlin, P., & Rios, P. (1989). Recognition and expression of

emotional cues by autistic and normal adults. *Journal of Child Psychology and Psychiatry*, 30(6), 865-877.

Merrell, K. W., & Gimpel, G. A. (1998). *Social skills of children and adolescents: Conceptualization, assessment, treatment*. Mahwah, NJ US: Lawrence Erlbaum Associates Publishers.

Mischel, W., & Shoda, Y. (1995). A cognitive-affective system theory of personality: reconceptualizing situations, dispositions, dynamics, and invariance in personality structure. *Psychological review*, 102(2), 246.

Morris, R. R., Kirschbaum, C. R., & Picard, R. W. (2010). Broadening accessibility through special interests: a new approach for software customization. Proceedings from the 12th international ACM SIGACCESS conference on Computers and accessibility.

Moore, D. (1998). Computers and people with autism/asperger syndrome. *Communication, summer*, 20-21.

Moore, D., McGrath, P., & Thorpe, J. (2000). Computer-aided learning for people with autism – a framework for research and development. *Innovations in Education & Training International*, 37(3), 218-228.

Muenchen, R. A. (2012). The popularity of data analysis software. *UR L* <http://r4stats.com/popularity>.

Myles, B. S., & Southwick, J. (2005). *Asperger syndrome and difficult moments: Practical solutions for tantrums, rage, and meltdowns*. Shawnee Mission, KS: Autism Asperger Publishing Company.

Osterling, J., & Dawson, G. (1994). Early recognition of children with autism: A study of first birthday home videotapes. *Journal of autism and developmental disorders*, 24(3), 247-257.

Pelphrey, K. A., Morris, J. P., & McCarthy, G. (2005). Neural basis of eye gaze processing deficits in autism. *Brain*, 128(5), 1038-1048.

Ramdoss, S., Machalicek, W., Rispoli, M., Mulloy, A., Lang, R., & O'Reilly, M. (2012). Computer-based interventions to improve social and emotional skills in individuals with autism spectrum disorders: A systematic review. *Developmental Neurorehabilitation*, 15(2), 119-135.

Riby, D. M., Doherty-Sneddon, G., & Bruce, V. (2009). The eyes or the mouth? Feature salience and unfamiliar face processing in Williams syndrome and autism. *The Quarterly Journal of Experimental Psychology*, 62(1), 189-203.

Roeyers, H. (1995), Belgium: A peer-mediated proximity intervention to facilitate the social interactions of children with a pervasive developmental disorder. *British Journal of Special Education*, 22: 161–164.

Rogers, S. J. (2000). Interventions that facilitate socialization in children with autism. *Journal of Autism and Developmental Disorders*, 30(5), 399-409.

Rump, K. M., Giovannelli, J. L., Minshew, N. J., & Strauss, M. S. (2009). The development of emotion recognition in individuals with autism. *Child development*, 80(5), 1434-1447.

Russo-Ponsaran, N. M., Evans-Smith, B., Johnson, J., Russo, J., & McKown, C. (2015). Efficacy of a Facial Emotion Training Program for Children and Adolescents with Autism Spectrum Disorders. *Journal of Nonverbal Behavior*, 1-26.

- Rutherford, M. D., Baron-Cohen, S., & Wheelwright, S. (2002). Reading the mind in the voice: A study with normal adults and adults with Asperger syndrome and high functioning autism. *Journal of autism and developmental disorders*, 32(3), 189-194.
- Rutherford, M. D., Clements, K. A., & Sekuler, A. B. (2007). Differences in discrimination of eye and mouth displacement in autism spectrum disorders. *Vision Research*, 47(15), 2099-2110.
- Ryan, C., & Charragáin, C. (2010). Teaching emotion recognition skills to children with autism. *Journal of Autism and Developmental Disorders*, 40(12), 1505-1511.
- Savery, J. & Duffy, T.M. (1996). Problem based learning: An instructional model and its constructivist framework. In B.G. Wilson (Ed.), *Designing constructivist learning environments*. Englewood Cliffs, NJ: Educational Technology Publications.
- Schunk, D. H. (1989). Social cognitive theory and self-regulated learning. In *Self-regulated learning and academic achievement* (pp. 83-110). Springer New York.
- Sehaba, K., Estraillier, P., & Lambert, D. (2005). Interactive educational games for autistic children with agent-based system. *Entertainment Computing-ICEC 2005*, 422-432.
- Shaw, M. L., & Gaines, B. R. (2012). WebGrid: Knowledge Elicitation and Modeling on. *Industrial Knowledge Management: A Micro-level Approach*, 335.
- Shaw, S. (2001). Behavioral treatment for children with autism: A comparison between discrete trial training and pivotal response training in teaching emotional perspectivetaking skills. *Dissertation Abstracts International*, 61, Retrieved from PsycInfo database (AAI9996460)
- Silver, M., & Oakes, P. (2001). Evaluation of a new computer intervention to teach people with

autism or Asperger syndrome to recognize and predict emotions in others. *Autism*, 5(3), 299-316.

Simpson, R. L., Myles, B. S., LaCava, P. G., Simpson, R. L., & Myles, B. S. (2008).

Understanding and responding to the needs of children and youth with autism spectrum disorders. *Educating children and youth with autism*, 1-60.

Smith, A. (2013). Smartphone ownership—2013 update. *Pew Research Center: Washington DC*, 12.

Solomon, M., Goodlin-Jones, B. L., & Anders, T. F. (2004). A Social Adjustment Enhancement Intervention for High Functioning Autism, Asperger's Syndrome, and Pervasive Developmental Disorder NOS. *Journal of Autism and Developmental Disorders*, 34(6), 649-668.

Sorce, J.F., Emde, R.N., Campos, J.J., & Klinnert, M. D. (1985). Maternal emotional signaling: Its effects on the visual cliff behavior of one-year-olds. *Developmental Psychology*, 20, 195-200.

Stafford, N. (2000). Can emotions be taught to a low functioning autistic child? *Early Child Development and Care*, 164105-126.

Stichter, J. P., Randolph, J., Gage, N., & Schmidt, C. (2007). A review of recommended social competency programs for students with autism spectrum disorders. *Exceptionality*, 15(4), 219-232.

Strijbos, J. W., Kirschner, P. A., & Martens, R. L. (2006). What we know about CSCL. In *What We Know About CSCL* (pp. 245-259). Springer Netherlands.

Swaggart, B., Gagnon, E., Bock, S., & Earles, T. L. (1995). Using social stories to teach social

- and behavioral skills to children with autism. *Focus On Autistic Behavior*, 10(1), 1-16.
- Swettenham, J. (1996). Can children be taught to understand false belief using computers? *Journal of Child Psychology and Psychiatry*, 37(2), 157-165.
- Tanaka, J. W., Wolf, J. M., Klaiman, C., Koenig, K., Cockburn, J., Herlihy, L., & Schultz, R. T. (2010). Using computerized games to teach face recognition skills to children with autism spectrum disorder: The Let's FaceIt! program. *Journal of Child Psychology and Psychiatry*, 51(8), 944-952.
- Tseng, R. Y., & Do, E. Y. L. (2010). Facial expression wonderland (FEW): a novel design prototype of information and computer technology (ICT) for children with autism spectrum disorder (ASD). Proceedings from the 1st ACM International Health Informatics Symposium.
- Wallace, S., Coleman, M., & Bailey, A. (2008). An investigation of basic facial expression recognition in autism spectrum disorders. *Cognition and Emotion*, 22(7), 1353-1380.
- Weinger, P. M., & Depue, R. A. (2011). Remediation of deficits in recognition of facial emotions in children with autism spectrum disorders. *Child and Family Behavior Therapy*, 33(1), 20-31.
- Yirmiya, N., Sigman, M. D., Kasari, C., & Mundy, P. (1992). Empathy and cognition in highfunctioning children with autism. *Child Development*, 63(1), 150-160.
- Zimmerman, B. J. (1989). A social cognitive view of self-regulated academic learning. *Journal of educational psychology*, 81(3), 329.

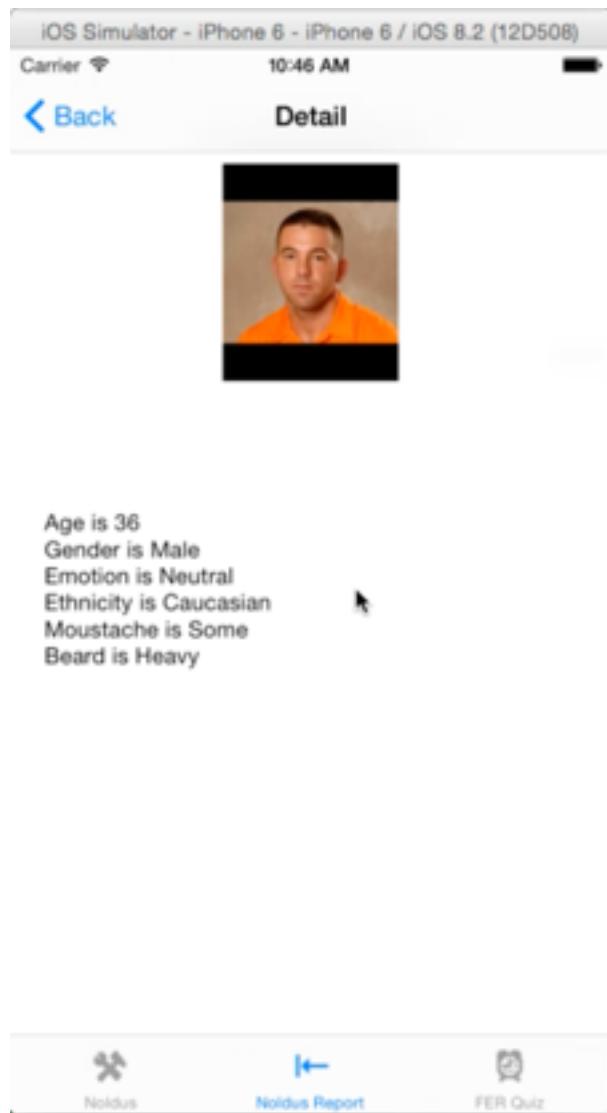
**Figure 2 - Mode 1 screenshot**

This is the screenshot of the prototype app in mode 1 in which users can access faces from the MPI Facial Expression Database. Users can use the spinning wheel below the image to select their answers as to an FER quiz.



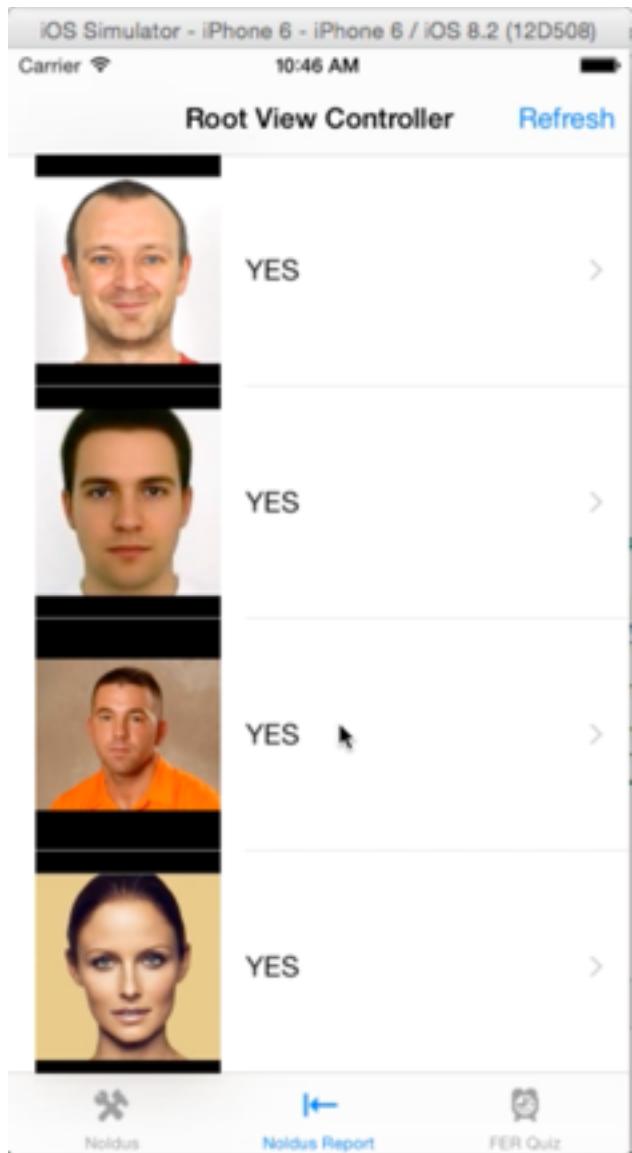
**Figure 3 - Mode 2 screenshot**

This is the screen shot of the prototype app in mode 2 in which users can send their photos to FaceReader on the Noldus server for analysis.



**Figure 4 - Mode 2 screenshot, image directory**

This is a screenshot of the prototype app in mode 2 showing users a directory of their images which have been analyzed by FaceReader.



## **Appendix A — Personal correspondence Jan. 21, 2015**

The following two emails are from the researcher to the app developer. All identifying information about the app developer has been removed.

University of Ontario Institute of Technology Mail - xcode file

2016-07-28, 11:58 PM



Michael O'Connor <michael.oconnor@uoit.net>

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### **xcode file**

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Michael O'Connor <michael.oconnor@uoit.net>  
To:

Sun, Jun 21, 2015 at 11:57 PM

Hi,

I downloaded your files and a copy of Xcode. I've run the file through the simulator, but doesn't make a lot of sense to me as the app doesn't seem to be fully functioning. Could you set up a time this week to talk by phone? I wanted to go through what I see in the simulator.

Mike

## Appendix B — Personal correspondence Oct. 24, 2015

University of Ontario Institute of Technology Mail - final stages of autism app

2016-07-28, 11:09 PM



Michael O'Connor <michael.oconnor@uoit.net>

### final stages of autism app

Michael O'Connor <michael.oconnor@uoit.net>

Sat, Oct 24, 2015 at 11:23 PM

To: Roland van Oostveen <ROLAND.VANOOSTVEEN@uoit.ca>

Cc: Roland van Oostveen <ROLAND.VANOOSTVEEN@uoit.ca>

Hi ,

I've been thinking a lot about the problem with the app. Without a usable app, I can't proceed with my study and without the study, I have no thesis. And without a thesis I won't graduate. I have spent two years working on this thesis and study. We have spent the entire budget for the study on you. With the changes and a little debugging I can continue and have my masters by the spring.

When you signed on to this project you agreed to debug the app and do some fine tuning. You haven't done that. And this is a common practice in all app development. I appreciate you being busy. I run my own company, teach at York University, and am completing my masters. I'm also the sole income earner for a family of four.

I'm not asking for a lot of changes, but I am asking that you finish what you agreed to do. And I'm appealing to you as a fellow student, who is very pressed for time, don't force me to throw away two years of research because you can't make these changes. Below are the changes I'm asking for.

Mike

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#### Changes needed for ER app

1. On the opening screen there needs to be the following explanation of the app:

"This app helps people with Autism learn facial expressions. You can examine facial expressions and test your skills using photos taken by you or from the built-in database."

The user needs to touch the screen to acknowledge they have read the explanation.

2. In the feedback from the facial expression tests, please do not display the information about race identification.
3. Change the button named "Noldus Server" to "Check facial expression".
4. Many people with autism have problems with their fine motor abilities. Please make the swiping actions and spinning of rotors less sensitive and move a little slower so it is less likely they will have problems accidentally swiping the screen.
5. I need to insert another button called "Support". When click on that, it should open up their browser and take them to a website I have built to help the users of the app.
6. I also need a way to be able to show the app to members of thesis advisory committee. I would prefer them not have to load this on Xcode and explain to them how to operate Xcode.