User Interface Adaptability within an Augmentative Communication App for Children with Autism Spectrum Disorder

by

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Abstract

For individuals working in the field of education and early intervention, facilitating communication is considered the first step to developing learning interventions for individuals with autism spectrum disorder. The introduction of tablets and augmentative communication apps is changing the way that communication is being approached, opening up an entirely new area of research surrounding the effectiveness of these devices as communication tools. However, there is presently no clear set of criteria to identify which interface settings could work best for each individual with autism spectrum disorder. This study focused on the user interface of Proloquo2Go and specifically looks at the effect that button size and array size has on the usability of the app for individuals with autism spectrum disorder. It was found that 2 of 3 participants exhibited similar response rates and patterns of use with the app across all phases of the study, showing low influence of button size and array size. The third subject had a number of maladaptive behaviours which interferred with his ability to participate in the study, not allowing for any conclusions about usability to be made from his data. Further research is needed in the area of user interface characteristics for individuals with autism spectrum disorder to draw solid conclusions about a relationship between button size/array size and usability for individuals with autism spectrum disorder.

Table of Contents

List of Tables

List of Figures

User Interface Adaptability within an Augmentative Communication App for Children with Autism Spectrum Disorder

Communication is an important part of day to day functioning within society. It allows us to interact with one another and understand the wants, needs, feelings and expectations of people in our lives. The skill of communication begins its development in early infancy when a baby cries to get its needs met and is refined through the lifespan into spoken and then written forms. When this development is impaired or taken out of the typical developmental trajectory, we see an impact on many other aspects of development such as social development and language skills.

Communication disorders are difficulties with communication and other related functions (Gleason, 2001). These disorders can range from difficulty producing sounds to complete inability to understand spoken language. For a communication disorder to be diagnosed, the difficulty must significantly interfere with the individual's quality of life (American Psychiatric Association, 2013). Functioning within society is impaired for individuals with these disorders, impacting their ability to interact with other people and access new information. Vygotsky (1962) theorized that thought and speech are closely related processes that must be associated in order to exist. Without the ability to form concrete labels for items, humans would not be able to move out of basic levels of thought in which we are simply reacting to our environments. Vygotsky felt that this ability to develop a link between symbols and our environment is what truly separates us from animals and allows us to develop higher level skills such as problem solving. Academic performance and learning are difficult for people with communication disorders (American Speech-Language-Hearing Association [ASHA], 2005). They are often unable to follow simple instructions, understand spoken language or read and understand social cues. Communication is critical for ongoing learning to occur, the ability to participate in interactive communication is essential for the success of students in school and beyond (ASHA, 2005). Communication disorders may exist individually or co morbidly with other diagnoses such as autism spectrum disorder.

Difficulty with communication is considered one of the key indicators when a diagnosis of autism spectrum disorder (ASD) is given (American Psychiatric Association, 2013). For individuals working in the field of autism intervention, facilitating social communication is considered one of the first steps to a successful learning intervention. Developing communication skills lays the building blocks for all other learning to occur. Once a child is able to communicate their wants and needs, and understand the communication attempts of other people, many barriers to learning are removed. As autism spectrum disorder is qualified as a “spectrum disorder”, the levels of impairment in communication can vary substantially among individuals with such a diagnosis.

Communication impairment in individuals with autism spectrum disorder can present itself as a severe language delay, which can take the form of very limited language production or use of only single words. It appears that a substantial portion of children with ASD have a severe language delay. Wodka, Mathy and Kalb (2013) found that data from the Simon Simplex Collection, showed that 40% of children at age of 8 (n=1456) had no phrase speech or an onset of phrase speech after age 4. The Simons Simplex Collection (SSC) is a core project of the Simons Foundation Autism Research Initiative (SFARI). In partnership with 12 university-affiliated research clinics, SFARI has established a repository of genetic samples and associated data from 2 600 families with one child (aged 4-18) with ASD and no first, second or third degree relatives with ASD (Simons Foundation, 2015). The term 'non-verbal' is often used to refer to children with ASD who show very limited expressive language output (American Psychiatric Association, 2013).

Although differences in motor development are not considered primary diagnostic categories for ASD, researchers interested in autism are increasingly considering the importance of motor functioning of children with ASD in the areas of diagnosis, influence on behaviours and treatment (Provost, Lopez & Heimerl, 2007). The area of motor skills delay has been heavily researched with school aged children with autism spectrum disorder, however looking at motor skills in early childhood for children with autism spectrum disorder is still an emerging field. Provost et al. (2007) conducted a study with 56 children aged 21-41 months with autism spectrum disorder, developmental disorders or developmental concerns with no motor delays. They found that all children in their study with autism spectrum disorder had delays in fine motor skills, gross motor skills or both. Motor skill development may also impact communication, as it can be related to the production of speech with oral motor skill development. Gernsbacher, Sauer, Geve, Schweigert & Goldsmith (2008) proposed that motor skills may be an important factor when determining if children with autism will develop speech and to what degree, directly impacting their ability to communicate.

A variety of Augmentative and Alternative Communication (AAC) methods have been traditionally used to facilitate communication for individuals with autism spectrum disorder such as sign language, communication boards, speech generating devices and picture exchange. Some interventions have inherent limitations for communication, such as sign language which requires a trained communication partner and communication boards which require the child to accurately point. Traditional speech therapy and sign language both require basic attending skills such as sitting, looking at a therapist and imitating simple actions and sounds (Bondy & Frost, 1994).

They assume that attending and imitation skills are prerequisites to learning functional language. It was also found that many AAC techniques relied on the teacher initiating the beginning of a social interaction, rather than teaching the child to initiate (Bondy & Frost, 1994). The advances made in the last 25 years to this treatment area are significant and have enabled many non-verbal individuals with ASD to communicate effectively (Schlosser, 2003). From sign language and static communication boards to picture-based systems, to the rapid development of speech generating devices and the introduction of tablet-based speech generating devices, individuals with a need for AAC have more options than ever. One of the major breakthroughs in the area of AAC has been the realization that simply providing a device is not a guarantee that it will be used functionally. There is more to using a device than simply choosing the correct one, you must also use a systematic empirically-validated training procedure (Sigafoos, 2005).

The Picture Exchange Communication System (PECS) was developed by Bondy and Frost in 1994 to train children to use a picture-based functional communication system in response to this need for a systematic training procedure. Past training programs had never been tried with children younger than 5 or involved the social context as heavily as PECS. Children initially learn to request items by selecting a small picture card and giving it to another person. This not only allows the child to access an item that they desire, but they also begin to associate another person with desired outcomes. The PECS training protocol uses the principles of Applied Behaviour Analysis (ABA) to reinforce communication attempts through specific prompting, reinforcement and error correction strategies. This system gradually increases complexity and expectations until individuals are able to use multiple cards to compose sentences for a variety of communicative purposes (requesting, labeling, answering questions, etc) and travel across distances to gain another person's attention (Bondy & Frost, 2001). The PECS protocol has been found to be an effective way to stimulate language production by numerous studies (Charlopp-Christy, Carpenter, Le, LeBlanc & Kellet, 2002; Ganz & Simpson, 2004; Ganz, Davis, Lund, Goodwyn & Simpson, 2012; Preston & Carter, 2009; Sulzer-Azaroff, Hoffman, Horton, Bondy & Frost, 2005; Yoder & Stone, 2006). In 2008, The National Professional Development Centre (NPDC) on Autism Spectrum Disorder (ASD) adopted the Picture Exchange Communication System as one of 24 evidence-based practices for ASD (Wong et al., 2014).

Many researchers and educators have had success using the PECS protocol for children with autism spectrum disorder (Ganz et al., 2012; Preston & Carter, 2009; Sulzar-Azaroff et al., 2009). The PECS protocol has been found to increase communication attempts, stimulate verbal language production and decrease maladaptive behaviours in children with autism spectrum disorder (Ganz et al., 2012; Preston & Carter, 2009; Sulzer-Azaroff et al., 2009). However, certain limitations exist with this program (Chien et al., 2015; DeLeo, Gonzales, Battagirl & Leroy, 2011). The requirement to use a card with an image of an item on it creates many limitations. The production of picture cards can be a lengthy process: you must take the picture, upload it to a computer, make it the correct size, print, laminate and then add Velcro to the back. These pictures then create large binders that contain every 'word' that the child may use. Pictures also become damaged or lost frequently and must be replaced creating constant upkeep. The process of making the pictures takes much of the spontaneity out of communication.

The recent development of touch-based tablet technologies presents us with the opportunity to directly deal with many of these limitations, and possibly revolutionize the area of augmentative and alternative communication for non-verbal individuals with autism spectrum disorder. In 2014 there were over 300 communication apps available for Apple mobile devices on the iTunes store, a number that has grown exponentially since 2009 when there were 3 apps available (Spectronics, 2014). Many of these apps have developed their interfaces based on the traditional PECS picture cards; however the digital format has removed many of the limitations that came with the traditional paper cards. Users are now able to take a picture with their device, share it into the app and then use the device to communicate within only a few seconds.

Much of the current research into the use of augmentative communication apps has focused on their effectiveness as a communication tool. A number of studies have shown that touch-based tablets in combination with AAC apps are an effective tool to increase communication for non-verbal children with ASD (Achmadi et al., 2012; Flores et al., 2012; Rispoli**,** Franco, van der Meer, Lang & Carmargo, 2010; van der Meer et al., 2012b). Using AAC apps increased communication in comparable levels to PECS and sign language (van der Meer et al., 2012b). It was also found that many children preferred using the AAC apps over traditional methods of communication, increasing their motivation to use the devices (van der Meer et al., 2012a).

The widespread accessibility and use of touch-based tablets and smart-phones has increased the availability of these devices for use as AAC devices. Traditional speech generating devices that were used as AAC devices were prohibitively expensive and difficult for many potential users to access. Despite having older technology many purpose built AAC devices are more than 15 times more expensive than mainstream tablets (Dolic**,** Pibernik & Bota, 2012). Dynavox is one company that manufactures purpose build AAC devices. Their Maestro devices start at $4 599.00 and increase to more than $8 000 for a more advanced model (Assistive Technology Lending Centre, 2015). The Accent AAC system starts at $6 525.00 for their smallest model and increases to $15 945.00 for a deluxe model (Assistive Technology Lending Centre, 2015). This significant cost lead app developers to begin creating applications that could be used on readily available tablets as an option for families. Developers of applications for tablets and smart phones are also beginning to include inclusive design aspects to their apps, allowing for accessibility within current apps and looking towards the integration of AAC functionality within apps (Dolic et al., 2012).

The tablet technologies have revolutionized the field, but they have also created a number of challenges. The number of apps on the market and the adaptability of each user interface means that educators and speech pathologists must often use a trial and error method of testing various communication techniques and their user interface settings, wasting both time and resources. A clinical model of choosing the best augmentative communication app for an individual is currently being proposed by Gosnell, Costello and Shane (2011) utilizing the process of feature matching developed in 1994 by Shane and Costello. This model begins by evaluating a person's strengths and needs in an assessment. This information is then used to compare with up to 11 features of commercially available AAC apps, to select the best app for the individual. This model looks at differences between apps, but does not yet approach different settings within individual apps.

To address issues around user interface design and the use of different devices, Dolic et al. (2012) has proposed a model of adaptable symbol based AAC application for mainstream mobile devices, taking into account device dependable configuration and user dependable configuration. This model would develop standards that app developers could use when creating new apps for augmentative communication. Currently developers must utilize generic user interface standards that often don't take the needs of specialized populations into account. However, this model still requires that users determine preferences regarding symbol type, size, graphic user interface layout and the use of colour and animation before utilizing the model.

One tablet based AAC app that is growing in rapid use in research and educational settings is Proloquo2Go. Proloquo2Go is an augmentative communication app that uses symbols/pictures and text to generate speech. It was developed in 2009 by AssistiveWare for use on iOS devices and has featured many updates since its creation (AssistiveWare, 2015). The user interface of Proloquo2Go is similar to the paper format used for PECS and allows for a high level of customization to suit each individual learner. Research has shown that Proloquo2Go is an effective means of increasing communication for individuals with autism spectrum disorder **(**Kagohara et al., 2010; King et al., 2014; Lorah et al., 2013; Lorah, Parnell, Whitby & Hantula, 2014; Sigafoos et al., 2013; van der Meer, Sigafoos, O'Reilly & Lancioni, 2011**).** These researchers are currently exploring different ways to teach the use of this app to individuals with autism spectrum disorder. Many research studies do not look at different ways of teaching the use of the app, but simply whether the app increases communication. King et al. (2014) had success using an adapted form of the PECS protocol but encourage further research to look at additional exploration of this technique in comparison to others.

This study will be an exploration of the characteristics of individuals with autism and the characteristics of the user interface settings within an augmentative communication app, working towards determining which user interface settings work best for each individual. For the purpose of this study we will be looking at the relationship that button size and array size, within Proloquo2Go, has on the usability of the app for children with autism spectrum disorder.

Literature Review

To gain a deeper understanding of the context of this research it was important to review work that has been done up until now on autism spectrum disorder, augmentative and alternative communication, and user interface design. This literature review will examine the characteristics of individuals with autism spectrum disorder, applications of augmentative and alternative communication techniques and user interface design in an effort to build an understanding of the potential for adapting user interface characteristics of apps for individuals with autism spectrum disorder**.** At this time the literature review was approached from an exploratory perspective, allowing for the emergence of themes and relevant areas of research throughout the process. The establishment of these themes will allow for a more systematic review of the literature before beginning future research in this area.

In the area of autism spectrum disorder, studies on communication impairments and motor deficits were examined. Augmentative and alternative communication was examined from the perspective of traditional forms of intervention such as sign language, speech generating devices and picture exchange systems and then moving into more recent tablet computer based interventions. In the area of user interface design the current review of the literature focused on the aspects of iconicity, button size and array size, and display style.

Autism Spectrum Disorder

The term “autism spectrum disorder” is used to identify a range of disorders characterized by problems with communication skills, difficulties with social interaction and repetitive patterns of behaviour, interests or activities (American Psychiatric Association, 2013; Turkington & Anan, 2007). For a diagnosis of autism spectrum disorder, abnormal or impaired development must occur during the early developmental period before age 3 (World Health

Organization, 2008). In addition to autism spectrum disorder, many individual are also diagnosed with intellectual and/or language impairment, motor deficits and sensory impairments (American Psychiatric Association, 2013). Each individual will display patterns of behaviour that are unique but fit into the overall diagnosis of autism spectrum disorder (Turkington & Anan, 2007). The patterns of behavior seen in individuals with autism spectrum disorder vary greatly across individuals and within an individual over their life (National Research Council, 2001). These individual differences in language development, communication, motor skills, adaptive behavior and cognitive abilities have significant effects on the presentation of the disorder and potential outcomes. It is important that these individual differences are taken into account when planning educational goals and strategies (National Research Council, 2001).

Communication Impairments. Individuals with autism spectrum disorder show a wide range of abilities and skill development, and this remains true for their ability to communicate with others. Communication impairments in individuals with autism spectrum disorder range from failure to develop any speech to the development of functional, but idiosyncratic use of speech and language (Lord & Paul, 1997).

Approximately 50% of individuals with autism are unable to develop speech that is sufficient to meet their daily communication needs (American Psychiatric Association, 2013; Lord & Paul, 1997; National Research Council, 2001). For these individuals when speech is developed, there are often impairments in aspects of speech such as the ability to initiate or sustain communication, articulation difficulties and trouble with both spoken and written language comprehension (Baron-Cohen, 1988). Children with autism spectrum disorder have difficulty with the acquisition of speech and language, but also have difficulty with understanding language and nonverbal behavior in communicative situations (National Research

Council, 2001). In the absence of a means to communicate, children with autism spectrum disorder may develop idiosyncratic, unconventional, or inappropriate ways to communicate. Self-injurious behavior, aggression and tantrums are often used to gain attention, escape from a task or situation, or protest against changes in routine (Lord & Paul, 1997). This can create maladaptive behaviour patterns that can negatively impact the individual's ability to successfully function both within their family unit and other settings.

Bristol (1984) found that the severity of communication impairment in children with autism spectrum disorder may be one of the most stressful aspects of the disorder for families. The level of communication proficiency that individuals with autism spectrum disorder can develop has been found to be an important predictor of potential outcomes of successful adaptation and functioning throughout the life span (Garfin & Lord, 1986; McEachin, Smith & Lovaas, 1993).

Venter, Lord and Schopler (1992) found that the presence of fluent speech before the age of 5 was a good indicator of IQ scores, language measures, adaptive skills and academic achievement in adolescence. This makes communication development a priority for both families of individuals with autism and the professionals that work with them.

Motor Deficits. The current diagnostic criteria for autism spectrum disorder from either the World Health Organization or the American Psychiatric Association does not include motor impairments that impact voluntary or involuntary movements, despite the fact that numerous studies have shown the presence of impairments in these areas for individuals with autism spectrum disorder (American Psychiatric Association, 2013; World Health Organization, 2008). A 2007 study by Provost et al. found that all 19 of the subjects in their study (young children with autism spectrum disorder) had gross and/or fine motor skills below the normal/average range on the Bayley Scales of Infant Development (BSID) II Motor Scale and the Peabody Developmental Motor Scales, 2nd Edition (PDMS-2) motor skills assessments. A relationship between motor coordination scores and the severity of autism spectrum disorder was also identified in a study with 29 children by Dyck, Piek, Hay and Hallmayer (2007).

Various researchers have noted differences of fine and gross motor skills in school-aged children with autism spectrum disorder. Green et al. (2002) assessed the motor skills of children between the ages of 6 and 11 years old with a diagnosis of autism spectrum disorder using the Movement Assessment Battery for Children. This assessment is designed to assess motor skills including manual dexterity, ball skills and balance in children aged 4 to 12 years. They found that all children in the study with autism spectrum disorder scored below the 15th percentile on the test, with nine children scoring below the 5th percentile, indicating a definite motor problem.

A number of research studies have compared children with autism spectrum disorder to typically developing children. They found that children with autism spectrum disorder have delays or disorders in overall motor development, including locomotor and object control, manual dexterity, ball skills and balance, reach to grasp tasks, and graphomotor skills (Berkley, Zittel, Pitney & Nicols, 2001; Manjiviona & Prior, 1995; Mari, Castiello, Marks, Marraffa & Prior, 2003; Mayes & Calhoun, 2003). The data from these studies suggests that school aged children with ASD frequently present with motor delays ranging from subtle to significant. Overall the studies found that 50-73% of children with ASD in their study populations had significant motor delays compared to normative data.

Issues with motor control continue to be a concern for learning skills of school aged children with autism spectrum disorder. Cartmill, Rodger and Sivani (2009) reported that 40% of the caseloads of school-based occupational therapists were comprised of children with autism spectrum disorder. Of those cases 86% were referred for fine motor/handwriting difficulties (Cartmill et al., 2009). A study by Johnston et al. (2013) looked at handwriting skills of children aged 8-13 years with autism spectrum disorder. They utilized a tablet and stylus to have the children make cursive writing letters, and found that children with autism spectrum disorder had significantly larger stroke height and width, more variable movement trajectory and higher movement velocities; indicating significant instability of core handwriting movements.

The area of motor skills delay has been heavily researched with school aged children with autism spectrum disorder, however looking at motor skills in early childhood for children with autism spectrum disorder is still an emerging field (Provost et al., 2007).

Motor skills deficits may also impact communication as they can be related to speech development. It has been proposed that early development of oral and manual motor skills can distinguish children with autism spectrum disorder from typically developing children (Gernsbacher et al., 2008). Gernsbacher et al. (2008) also proposed that motor skills may distinguish between children with autism spectrum disorder that will develop minimal, moderate or fluent speech.

It is important that we take the motor skills of individuals with autism spectrum disorder into account when planning communication interventions, such as Augmentative and Alternative Communication (AAC) just as we do with individuals with more obvious motor challenges (Mirenda, 2008).

Autism spectrum disorder is a diagnosis that identifies individuals with a range of disorders involving impairment of communication and social interaction, and repetitive patterns of behaviour and interests (American Psychological Association, 2013; Turkington & Anan, 2007). Although they are not part of the formal diagnostic criteria, intellectual impairments, motor deficits and sensory impairments are often co-morbidly diagnosed. Interventions that are individualized and correctly implemented can help to build up communication and social skills, and decrease maladaptive behaviours for individuals with autism spectrum disorder (National Research Council, 2001).

Augmentative and Alternative Communication (AAC) Interventions

This section will describe a variety of AAC methods that have been used, beginning with traditional analogue versions and moving through to the more recent digital tablet-based AAC interventions that are becoming more common. Historically many types of interventions have been used with individuals with autism spectrum disorder to address skill deficits and decrease maladaptive behaviour. Augmentative and alternative communication (AAC) is one such area of intervention, which focuses on communication deficits and building the ability and motivation for individuals with autism spectrum disorder to communicate without the need for or ability to use verbal language.

Augmentative and Alternative Communication (AAC) is “an area of clinical practice that attempts to compensate (either temporarily or permanently) for the impairment and disability patterns of individuals with severe expressive communication disorders” (American Speech-Language-Hearing Association [ASHA], 1989, p.7). AAC can be adapted to support existing speech or develop the use of a non-speech symbol system such as sign language, exchange of visual symbols (pictures and/or words) and speech generating devices. AAC interventions, when properly used, are customized to each individual’s strengths and needs (National Research Council, 2001). For children with autism spectrum disorder, visual language systems represent specific communicative information in a static and predictable way, taking advantage of the strong visual processing ability that is a strength of many of these children.

AAC can be a useful part of an education program for children with autism spectrum disorder who do not acquire functional speech or have difficulty comprehending spoken language (National Research Council, 2001). Still**,** Rehfeldt, Whelan, May & Dymond (2014) found that all of the participants in the 16 studies they reviewed made gains from baseline in rates of communication with the use of at least one AAC (manual sign, picture exchange, or speech generating devices).

Traditionally communication has been encouraged for non-verbal individuals with autism and developmental disabilities through sign language, speech generating devices (SGD) or a picture exchange system (such as The Picture Exchange Communication System or PECS) (Rispoli et al,, 2010). Choosing which form of AAC is often one of the first struggles when attempting to increase a subject's communication (van der Meer et al., 2012b). It is also thought that preference can influence the effectiveness of an AAC system (van der Meer et al., 2012a). The introduction of the tablet computer and AAC specific apps is changing the way that communication is being approached, opening up an entirely new area of research surrounding the effectiveness of these devices as communication tools (Achmadi et al., 2012, Flores et al., 2012, van der Meer et al., 2012a).

A review of the literature by Rispoli et al. (2010) has shown that individuals with communication delays can effectively use a range of speech generating devices (SGDs) for functional communication. van der Meer et al. (2012b) have shown that more basic techniques such as manual signing and PECs can also be used to increase communication. With all of this supporting evidence, there is much debate within the literature as to which AAC method is best suited to individuals with autism. There does not seem to be one AAC system that is appropriate for all learners.

van der Meer et al., (2011) conducted a review of the literature surrounding preferences for AAC options for individual with developmental disabilities. In the 7 studies they reviewed, individuals were taught to use speech generating devices, picture exchange communication system (PECS) or manual sign language. Each study conducted assessments to identify preferences for each communication system. It was found that the majority of participants (67%) demonstrated a preference for SGDs. Results indicate that individuals often show preference of different AAC options and this should be taken into account when choosing interventions. van der Meer et al. (2012b) also showed that rate of acquisition of skills and maintenance of learned skills was better for preferred AAC options when comparing both sign language to SGDs and sign language to PECS to SGDs.

Research also does not show a clear picture of the effectiveness of one AAC technique over another. van der Meer et al. (2012a) found that 3 of 4 subjects preferred to use an iPod-based SGD app over manual signing; they also found that the subjects who preferred the SGDs showed faster skill acquisition and better maintenance of skills over time. This supports the idea that preference influences the effectiveness of an AAC technique. Flores et al. (2012) found that some subjects showed a definite preference for one technique over another, even to the point of one subject taking his paper PECS and throwing them in the garbage in an attempt to demand the iPad. They noted that the students showing this preference for the iPad-based SGD also showed the greatest increase in communication attempts using the SGD.

Sign Language. Sign language was developed as means of communication for individuals with hearing impairment. It is arguably the most widely recognized form of augmentative communication worldwide (Autism Canada, 2011). The use of sign language to develop communication skills with individuals with autism spectrum disorder has been a topic of much debate in the literature. Some clinicians feel that giving children a ready means of communication is important, regardless of potential limitations in breadth and sophistication of information (Schwartz & Nye, 2006). However the other school of thought focuses on the drawbacks of using a communication system which may never develop into a complete communication system. Schwartz and Nye (2006) conducted a review of the literature around the use of sign language for communication with individuals with autism spectrum disorder. They found that the literature around this topic was far from robust. Many of the studies that had been done and showed positive results involved single subject designs with no measures of treatment integrity or lack of detail that would allow for replication. Schwartz and Nye (2006) state that additional research must be done before a conclusion can be reached on potential benefits of teaching sign language. They did note as well that there was no evidence currently that using sign language with individuals with autism spectrum disorder is contraindicated at this time.

There are potential limitations that must be considered when choosing sign language as an AAC system. All potential communication partners must be trained in the use of sign language, restricting the number of people with which the individual can interact (Still et al, 2014). The motor impairments that are often co-morbid with autism spectrum disorder may also lead to difficulty in forming signs in a way that can be understood by all potential communicators (Provost et al., 2007). Seal and Bonvillian (1997) found that size of sign language vocabulary and accuracy of sign formation were highly correlated with fine motor skills in 14 students with autism spectrum disorder. The National Research Council (2001) suggests that simple signs may be a support for children learning to speak, however it does not generally develop into a comprehensive communication system and it is rare to find a child with autism spectrum disorder that signs fluently. As a result of this research, the use of sign language as an AAC intervention for children with autism spectrum disorder is declining. Many clinicians and educators are now turning to other areas of AAC for interventions to use with their students and patients.

Speech Generating Devices. Early Augmentative and Alternative Communication (AAC) technologies were analogue devices that allowed for alternative ways to select content from a static communication display, use of these devices was focused on face-to-face interactions mainly for persons with physical impairments (Beukelman & Mirenda, 2005; Shane, Blackstone, Vanderheiden, Williams & DeRuyter, 2012). The development of the microprocessor lead to its incorporation into dedicated AAC devices, known as speech generating devices, for use on personal computers and dedicated devices, leading to more options for individuals with communication needs. The more recent rapid evolution of mobile devices into powerful multimedia platforms has once again brought us to a new age of potential for AAC (Dolic et al., 2012; Shane et al., 2012).

As early as 1993, Durand found that a voice output system was effective not only for teaching individuals with ASD to request items/activities, but also resulted in a significant decrease in challenging behavior. Similar to the findings on studies done with picture exchange systems, speech generating devices have been shown to increase communication and decrease inappropriate behaviours in individuals with autism spectrum disorder (Durand, 1993; Trottier, Kamp & Mirenda, 2011). In two studies conducted in 2013, Boesch, Wendt, Subramanian and Hsu found that the outcomes for speech generating devices and picture exchange communication systems were similar both in terms of the speed of acquisition of skills and the development of social-communication behaviour and speech (Boesch et al. 2013a; Boesch et al., 2013b).

Picture symbols such as those used in picture based systems are often used on speech generating devices with pre-recorded, synthesized or digitized speech. This speech function enables individuals with autism spectrum disorder to not only communicate their needs, but also gain the attention of a communicative partner with the speech output feature (Schepis, Reid & Behrman, 1996).

In the last few years, the introduction of iPad/iPod Touch and speech generating Apps seems to have shifted the focus away from more traditional SGDs and onto the new technology. Flores et al. (2012) noted the increased interest in these devices and attributed it to portability, peer acceptance and convenience. Historically SGD devices, such as communication boards, often required a computer to program and were quite large and bulky, not allowing for easy programming and requiring assistance from an adult to transport the devices (See Tablet-based AAC for further information, p.21).

Picture Based Systems. Early picture based systems for communication were designed as static display boards with pictures or symbols arranged in a grid format. Individuals needed to point to or tap the picture which represented their desired response. These systems were difficult to use by children with autism spectrum disorder as it required many prerequisite skills such as matching, pointing and responding to questions. It was also often questioned whether children were attempting to spontaneously communicate or were engaging in self-stimulatory behaviour when they would repeatedly tap the boards. Bondy and Frost (1994; 2001) developed the Picture Exchange Communication System (PECS) in response to these concerns and to bring social interaction back into the communication exchange.

Picture Exchange Communication System (PECS). The Picture Exchange Communication System (PECS) is a structured program that teaches the exchange of symbols/pictures on laminated paper cards for communication (Bondy & Frost, 1994). PECS is a systematic program based on behavioural principles that teaches a child to initiate communication by approaching a communicative partner and exchanging the symbol for a desired item. It includes protocols for introducing the program and gradually building communication from single to multiple words and for introducing further functions such as labeling and commenting (Bondy & Frost, 1994). The pictures/symbols used for PECS training are usually laminated and stored in a binder which is carried by the user (see Figure 1).

Figure 1: Picture Exchange Communication System (PECS). A photograph of a Picture Exchange Communication System (PECS) binder of a young student with autism spectrum disorder.

Multiple reviews of the literature surrounding the acquisition of communication skills through the use of PECS have found positive results (Ganz et al., 2012; Preston & Carter, 2009; Sulzar-Azaroff et al., 2009). The PECS teaching protocol is an effective means of enabling individuals with autism spectrum disorder to communicate (Sulzar-Azaroff et al., 2009). PECS is readily learned by non-verbal individuals with and without a diagnosis of autism spectrum disorder (Preston & Carter, 2009). In a meta-analysis of 13 articles in 2012, Ganz et al. found that PECS users tend to make their largest gains on the targeted outcomes of functional communication consistently across student ages and the disability types of autism spectrum disorder, autism spectrum disorder with intellectual disabilities and autism spectrum disorder with multiple disabilities. They found uncertain results around a related increase in behavioural, social and speech skills, however feel confident saying that there is little indication that PECS has a negative influence on the development of these skills. Wide effect sizes in their analysis show that at least some PECS users made strong gains in some non-targeted areas such as reduction of challenging behaviour, increased levels socialization and increased speech output.

Although PECS is a widely recognized and effective system (Ganz et al., 2012; Preston & Carter, 2009; Sulzar-Azaroff et al., 2009), the set up and maintenance of the system can be both time and labor intensive (Chien et al., 2015; DeLeo et al., 2011). For the system to be effective, the PECS book must always be present which can create stress on families and difficulties when it is forgotten (Hayes et al., 2010). To set up a PECS program and maintain it, desired objects must be identified, photographed, printed, laminated, cut and have Velcro applied. It is also impractical for children to assist in this process due to the materials needed, creating a lack of participation and ownership of the process (Still et al., 2014). Portability of PECS systems is also a concern, as children learn they acquire more picture cards, which can turn into a large binder which can be difficult for a child to transport themselves (Chien et al., 2015). These limitations have lead to the development of AAC solutions utilizing mobile technology such as tablets.

Tablet-Based Alternative and Augmentative Communication (AAC). Recent developments in mobile technology have changed the way we all live, work and communicate.

The wide availability of portable, powerful technology is revolutionizing many aspects of day to day life. This revolution is not only influencing the daily lives of individuals without disabilities, it also has the potential to have dramatic effects on individuals with communication needs such as autism spectrum disorder. The new mobile technologies being introduced into the marketplace are frequently smaller and less expensive than traditional speech generating devices. They also have the added benefit of a multifunctional device that enables users to access a variety of apps in addition to their communication needs. In response to this need there has been an explosion of software applications for communication introduced into the marketplace and researchers have started to focus on the use of the iPad/iPod Touch to evaluate their effectiveness as a speech generating device for individuals with autism and developmental disabilities. (Flores et al., 2012; Gosnell et al.,2011; Hershberger, 2011; Kagohara et al., 2010; Lorah et al., 2014).

Tablet based AAC is an effective means of increasing communication for children with autism spectrum disorder (Flores et al., 2012; Kagohara et al., 2013; Lorah et al., 2014; Still et al., 2014). Flores et al. (2012) compared acquisition of communication between a picture exchange system and an iPad based SGD in preschool aged children with autism. They found that the rate of communication behaviours either increased with the use of the iPad or remained the same as with the picture-based communication system, showing that there was no decrease in communication as a result of using the iPad-based SGD. Lorah et al (2014) conducted a review of the literature and found that acquisition of communication skills was often quicker when using a tablet computer as compared to sign language or picture exchange programs. van der Meer et al. (2012a) found an increase in communication across 4 subjects with the introduction of an iPod based SGD; however 3 of the students also showed an increase in communication using sign language. Two reviews of the literature, summarizing 58 studies, provide support for the use of tablet based AAC in communication interventions with individuals with development disabilities, including autism spectrum disorder (Rispoli et al, 2010; van der Meer & Rispoli, 2010).

The sharp increase of availability of apps for AAC has opened up the market to many more families and potential users, however this switch from a clinical model to a consumer model has caused its own set of issues (Hershberger, 2011). The clinical model in which a clinical assessment was done by a psychologist, speech and language pathologist or medical doctor, usually involved the manufacturers of the AAC device who took on a support role for training the client, family and clinical team (Hershberger, 2011). In the consumer model we are seeing the emergence of "Over-the-Counter AAC," in which the clinical component has been eliminated in the choosing of a device and the implementation of the intervention. Parents may find their enthusiasm wane in the absence of clinical and technical support in teaching their children to use AAC apps. Hershberger (2011) is hopeful that we will see a meshing of the clinical and consumer model approaches in the future with more online support available to parents and clinical support for the use of tablet-based AAC.

With the recent increase in readily available AAC apps that can be used on various tablets there is also a potential issue with using different devices. A number of mobile devices can be used to deliver these apps from mobile phones to tablets and in some cases e-readers, many of them using different display technologies and sizes (Dolic et al., 2012). In the past the manufacturers of dedicated AAC devices had complete control over device specifications and software design, however now it is necessary for AAC apps to function on a variety of devices with a range of display types, sizes, resolutions, and refresh rates (Dolic et al., 2012).With this problem in mind in 2012, Dolic et al. proposed a model which would act as an adaptive system that would adjust the display of symbols and user interface settings to the specifications of different devices, and also to the capabilities and preferences of the user. The system would require the development of specially designed symbols that would enable change in size without loss of quality, which would enable users to use their AAC app across multiple devices. However the use of the proposed model still requires that upon initial use of the system the user or an assistant would set specific preferences regarding symbol type, size, graphic user interface layout and the use of colours. There is no proposed way to determine the preferences of each user within this model. Once the preferences are set, the program will automatically set minimum symbol size, maximum array size and colour taking into consideration the device being used and the size of the display. One important limitation that is included in the model is that user preferences may not exceed boundaries that the program determines in respect to the specifications of the system being used, maintaining the quality of the delivery of information to the user. The model proposed by Dolic et al. (2012) takes important first steps in looking at the delivery of AAC apps across multiple mobile devices and making a first attempt at proposing an additional program be developed to allow users to seamlessly use their AAC apps across multiple devices.

Selection of App for User. With the increased availability of AAC apps in the marketplace, many caregivers and educators of individuals with autism spectrum disorder are taking communication choices into their own hands instead of consulting speech and language pathologists or behaviour analysts. This has resulted in more accessible AAC for individuals with autism spectrum disorder but also has some potential drawbacks. Parents and educators may not have the background to select the best app, develop the most effective teaching method for each child, or modify user interface settings to best suit the needs of the user. This may result in

AAC apps being taught incorrectly, used inconsistently or abandoned without enough support for the family in learning to use the device for communication.

Gosnell, et al., (2011) outlined the importance of using a clinical approach to selecting communication apps for users. They emphasized a need to bring assessment and clinical experience back to this process. They proposed a model that is based on the feature matching process developed by Shane and Costello in 1994. The model begins by assessing a person's strengths and needs in an Augmentative and Alternative Communication (AAC) assessment. This information is then used by a clinician that is well versed in available apps on the market to compare features of communication apps. They have proposed a set of 11 main features of apps to use when feature matching apps to clients including the following criteria: purpose of use, output, speech settings, representation, display, feedback features, rate enhancement, access, motor competency, support and customization. They recommend using those criteria to assess the communication applications that are available and use information about the person's strengths and needs from assessments to determine the best fit. This model allows for the inclusion of new apps as they come available on the market. Further development, standardization and research using Gosnell et al.'s (2011) model is needed before it can be used confidently by clinicians and educators.

Kagohara et al., (2010) found that behavioral interventions can be used to overcome barriers to using speech generating iPad-based apps such as motor control problems. This type of intervention may be more efficient than replacing or modifying the SGD app or switching to another communication system when individuals have difficulty using the devices. There are also many prerequisite skills such as turning on the device and selecting the correct app required to independently use the devices for communication. Achamadi et al. (2012) found that advanced operations involved in using iPad-based speech generating apps, such as turning the device on, could be taught to students using techniques used in applied behavioural analysis such as response prompting, prompt fading and differential reinforcement. This would allow individuals to independently use their device as a communication tool.

Proloquo2Go. The most well known and widely researched tablet based AAC app that is currently on the market is Proloquo2Go. Proloquo2Go is an AAC application developed by AssistiveWare in 2009 for use on iOS devices. It includes over 14,000 SymbolStix symbols or can use photos taken on the iPad, iPod Touch or iPhone. It features a highly customizable interface which allows users to change many user interface design settings. The app also has settings to lock users from modifying buttons (to prevent accidental deletions) and restrict access on the device to only using that app (for communication specific devices). Lorah et al. (2014) found that 14 of the 17 studies in a systematic review on tablet-based AAC utilized an iPad or iPod Touch with Proloquo2Go.

Proloquo2Go has been shown to be an effective means of increasing communication for individuals with autism spectrum disorder (Kagohara et al., 2010; King et al., 2014; Lorah et al., 2013; Lorah et al., 2014; Sigafoos et al., 2013; van der Meer et al., 2011). Lorah et al. (2013) utilized Proloquo2Go for comparing the rate of requesting between a picture exchange system (not PECS) and an iPad-based SGD. They found that 4 of their 5 participants showed a higher rate of requesting using the SGD across training and maintenance. Sigafoos et al. (2013) were successful in increasing requesting the continuation of toy play across 2 children with autism spectrum disorder utilizing Proloquo2Go on an iPad. Unfortunately one of the limitations of research using Proloquo2Go is small sample sizes. In the systematic review done by Lorah et al.

in 2014, the sample sizes ranged from one individual to nine individuals. This makes it difficult to make wide reaching conclusions from this research.

The user interface design of Proloquo2Go is very similar to the paper format used for PECS. Some researchers have also started to adapt the teaching protocol from PECS to introduce Proloquo2Go to their participants. King at al. (2014) successfully used an iPad with the Proloquo2Go app to increase communication for three children aged 3-5 with autism spectrum disorder with a protocol adapted from The Picture Exchanged Communication System (Bondy & Frost, 1994; Bondy & Frost, 2001). Lorah et al. (2013) were also successful in using an adapted form of the PECS protocol to increase requesting in 4 of their 5 participants.

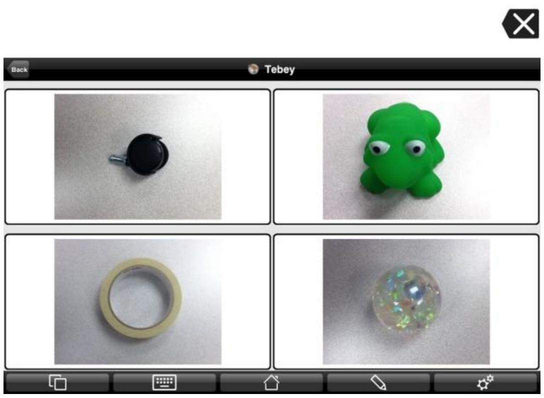
User Interface Design

The user interface design of Proloquo2Go and many other AAC apps is based upon the traditional paper PECS format. Individual words/pictures are in separate boxes presented in a grid format which replicates multiple PECS on a page in a binder (see Figure 2). Most apps also include a sentence strip across the top of the screen to assemble multiple icons together, similar to PECS phases 4-6 in which multiple picture cards are used together on a strip of Velcro to create sentences (Bondy & Frost, 1994).

Proloquo2Go features a highly adaptable user interface which has a number of features that can be customized, including but not limited to:

- line colour and thickness (around boxes)
- voice (for speech output)
- array size
- button size
- button spacing

- picture vs. symbol
- background colour
- vertical alignment
- inclusion of words
- font
- label position



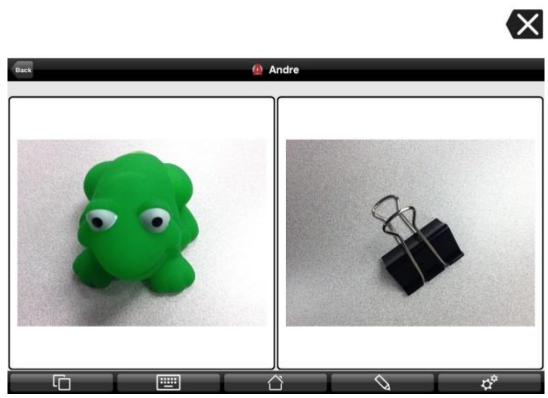


Figure 2 – Screen shots of User Interface of Proloquo2Go utilizing colour photographs in a 2x2 and 1x2 grid display.

For this study we will focus on the user interface design characteristics of iconicity, array size, button size and display style

Iconicity. Iconicity is defined as the visual resemblance between a symbol and its referent or the association that is formed (Brown, 1978). Iconicity is often referred to as a continuum; symbols that can be easily identified are referred to as transparent and at the opposite end are symbols with no obvious identification are opaque. Several studies have established a relationship between iconicity and ease of learning graphic symbols by individuals with developmental disorders (Fuller, 1997; Hurlbut, Iwata, & Green, 1982; Mirenda & Locke, 1989; Mizuko, 1987).

Kozleski (1991) found that children with autism required fewer learning trials to learn symbol sets that are associated with a higher level of iconicity or transparency. Mirenda and Locke (1989) observed that individuals with autism and developmental disabilities were able to learn a matching task much more easily with objects and identical colour photographs than with non-identical colour photographs, line drawings, Blissymbols or written words. In a more recent study Angermeier, Schlosser, Luiselli, Harrington and Carter (2008) did not find an influence of iconicity in the acquisition of Phases 1 and 2 of the PECs protocol which requires an exchange of a single picture card, without selecting the card from an array of pictures. This may be a direct result of Phases 1 and 2 only requiring an exchange and not discrimination of the picture, which results in not needing to look at the picture for a successful exchange. Picture discrimination is not introduced until Phase 3 of the PECs protocol, during which the individual must choose a desired picture from an increasingly large array (Bondy & Frost, 1994).

The iconicity hypothesis is often referred to in literature on iconicity (Angermeier et al., 2008; Koul, Schlosser & Sancibrian, 2001; Sclosser & Sigafoos, 2002). This hypothesis states that symbols with greater degrees of iconicity are more easily learned. There are numerous research studies whose results support the application of this hypothesis to graphic symbol learning in individuals with and without disabilities (Fuller, 1997; Koul & Lloyd, 1998; Mizuko, 1987; Mizuko & Reichle, 1989).

Proloquo2Go comes pre-programmed with Symbolstix symbols which are basic drawings assessed to be high in iconicity (See figure 3). However for the purposes of our study, we will be using colour photographs of the object to maintain the highest possible level of transparency in iconicity.

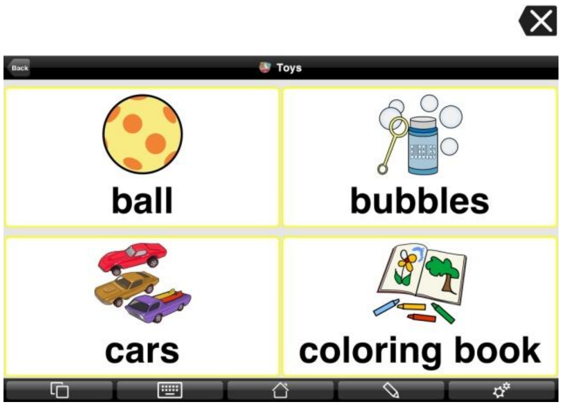


Figure 3 – Screenshot of User Interface of Proloquo2Go featuring pre-programmed Symbolstix icons in a 2x2 grid display.

Button Size and Array Size. There are a number of standards that have been developed for touch screen interface design. One of those is The American National Standards Institute (ANSI) developed by the Human Factors and Ergonomics Society (HFES) 100-2007 (2007) which recommends that touch screen interfaces have a button size of at least 9.5mm with a 3.2mm gap between buttons. This standard also states that there is no improvement in performance and usability with button sizes over 22mm. While this standard was heavily researched, it lacks information on how button size impacts individuals with motor control disabilities, such as many individuals with autism spectrum disorder (Chen, Savage, Chourasia, Wiegmann & Sesto, 2013).

Chen et al. (2013) found that in a task involving digit entry, people with motor control issues needed a much larger button size (30mm) to reach the same accuracy as individuals with no motor control issues had with smaller buttons (20mm). As the button size increased, they noted a decrease in misses (84% drop), errors (59% drop) and time to complete the tasks. Many of the research studies conducted to set touch screen interface design standards, did not reach a consensus on button size and did not include individuals with motor control issues (Chen et al., 2013).

Sesto, Irwin, Chen, Chourasia and Wiegmann (2012) found that touch characteristics, such as forces, impulse and dwell times, were significantly impacted by button size for individuals with motor control issues during a touch screen task. This could impact usability of sensitive touch screen interfaces such as the iPad, when used by individuals with motor control issues.

Within Proloquo2Go to modify the button size of the display, you must also modify the array size. As the array that is displayed becomes larger the buttons will display as smaller. As such, these factors will be examined together. This study will explore 4 configurations of Proloquo2Go, which will change the array size and button size that is displayed on the iPad.

Display Style. One user interface characteristic that may impact the use of an AAC display is the style of display. It seems likely that in a communication medium that is entirely visual the effectiveness of the intervention would be impacted by how effectively the information in the display can be identified and used (Wilkinson & Jagaroo, 2004).

Visual Scene Displays are a style of display in which representation of concepts are embedded in a full or integrated scene (Wilkinson, Light & Drager, 2012). Vocabulary associated with a scene is programmed into the scene creating ‘hotspots’ to represent language concepts. For example, a picture of the child’s own kitchen may be used, and touching the fridge could activate speech output of “fridge”. The application of these principles is an emerging area in AAC research, which has not yet identified which elements of a VSD make displays more or less effective. Wilkinson and Jagaroo (2004) noted that the clear structural differences between VSDs and traditional grid designs likely means that the visual processing demand on users is much different for each display style. Due to this fundamental difference they suggested that research that indicates the best practice for construction of grid-style displays may not transfer to VSDs. The addition of numerous items in a scene may also add to the visual processing load of the display, which may impact the usability for some users and make it difficult to determine a consistent level of complexity such as could be easily determined in a grid-style array (Wilkinson et al., 2012).

The user interface of Proloquo2Go utilizes a grid-style display, closely replicating a page in a PECS book, allowing for a consistent level of complexity.

Theoretical Framework

The theoretical framework for this study was developed to explore the adaptability of user interface characteristics within augmentative communication apps to the characteristics of individuals with autism spectrum disorder (See Figure 4). Specifically, the user interface characteristics of button size and array sized are manipulated to measure their influence on the ability of users with autism spectrum disorder to use the device.

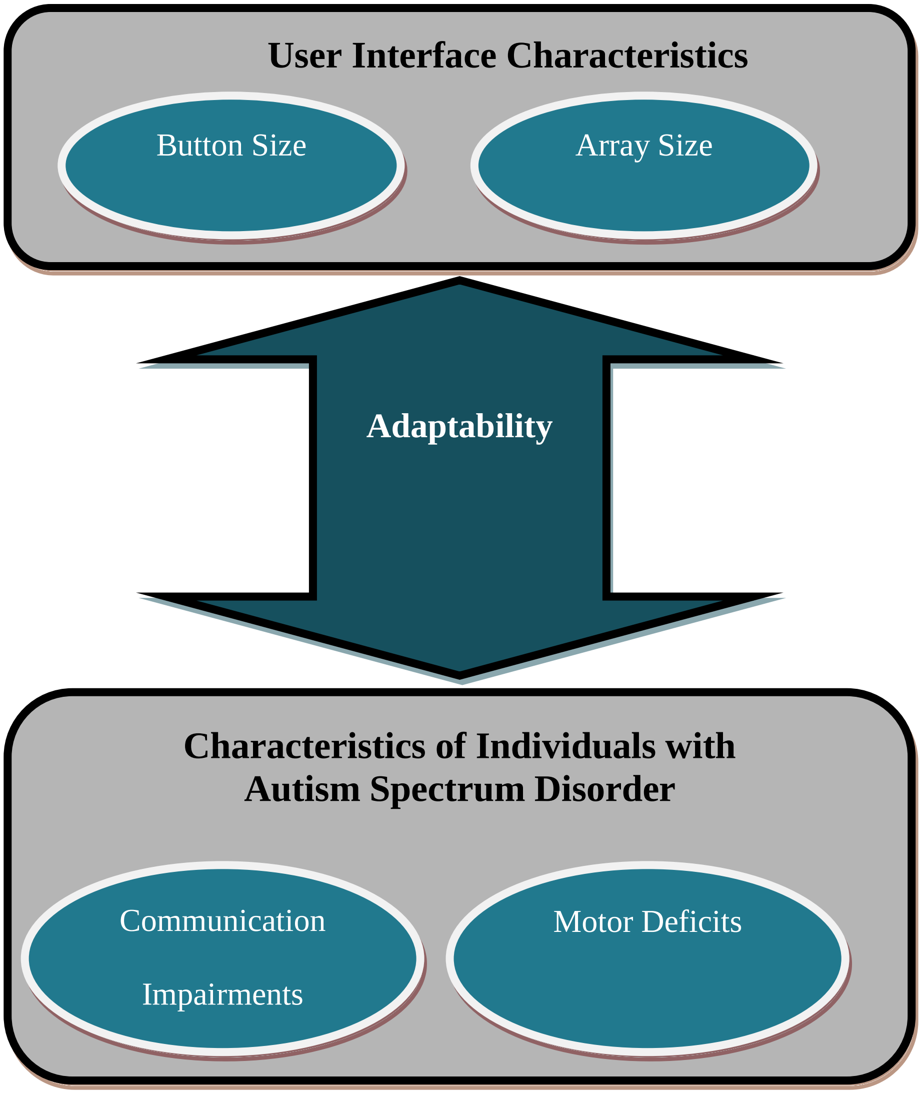


Figure 4 – Theoretical Framework exploring the adaptability of user interface characteristics of augmentative communication apps to the characteristics of individuals with autism spectrum disorder.

From the literature review it emerged that button size and array size are user interface characteristics that greatly influence the usability of an app for individuals with motor control issues. As the literature also shows us that individuals with autism spectrum disorder often have motor control issues, this shows that button size and array size may directly impact the usability of an app by individuals with autism spectrum disorder.

This study sets out to explore how user interface characteristics, within an AAC app, can be adapted to the characteristics of individuals with autism spectrum disorder.

Research Questions

Although a clinical model for choosing the best AAC app for each individual has been proposed by Gosnellet al. (2011), no similar model exists for selecting the best user interface settings within the apps. This study attempts to explore this topic by posing the following research questions:

1. How can current user interface characteristics on mobile technology be adapted to the characteristics of individuals with autism spectrum disorder?
2. How can the user interface within an augmentative communication app be adapted to the characteristics of individuals with autism spectrum disorder?
3. Does button size influence the usability of an app for individuals with autism spectrum disorder?

Methodology

When reviewing the methodologies commonly used in the area of AAC research it was noted that studies mostly utilized a case study design with one to three participants collecting quantitative data that focuses on increases/decreases in communication attempts from a baseline measure (van der Meet et al., 2011). Reviews of the literature by both Still et al. (2014) and van der Meer et al. (2011) found that the majority of studies reviewed utilized a multiple baseline design across activities and participants. For this study the goal was more exploratory, and so it was hoped that as the research occurred the adaptability data would emerge in a more qualitative way while also collecting quantitative data. For this to occur, the researcher needed a set up that would allow for data collection to take place while the researcher remained immersed in the sessions with the subjects and was able to adapt teaching procedures within each session.

The study was conducted in the Educational Informatics Lab (EI Lab) at the Faculty of Education, University of Ontario Institute of Technology (UOIT). The EI Lab features 4 ceiling mounted video cameras and wall mounted sound recording jacks allowing for non-obtrusive overhead observational video related to subject activity and interactions with devices to be captured. Data from multiple cameras, screen capture and audio will be recorded and synchronously stored for analysis (See Figure 5). The EI Lab will be configured using a floor plan which is designed for use with children (see Figure 6 and 7).

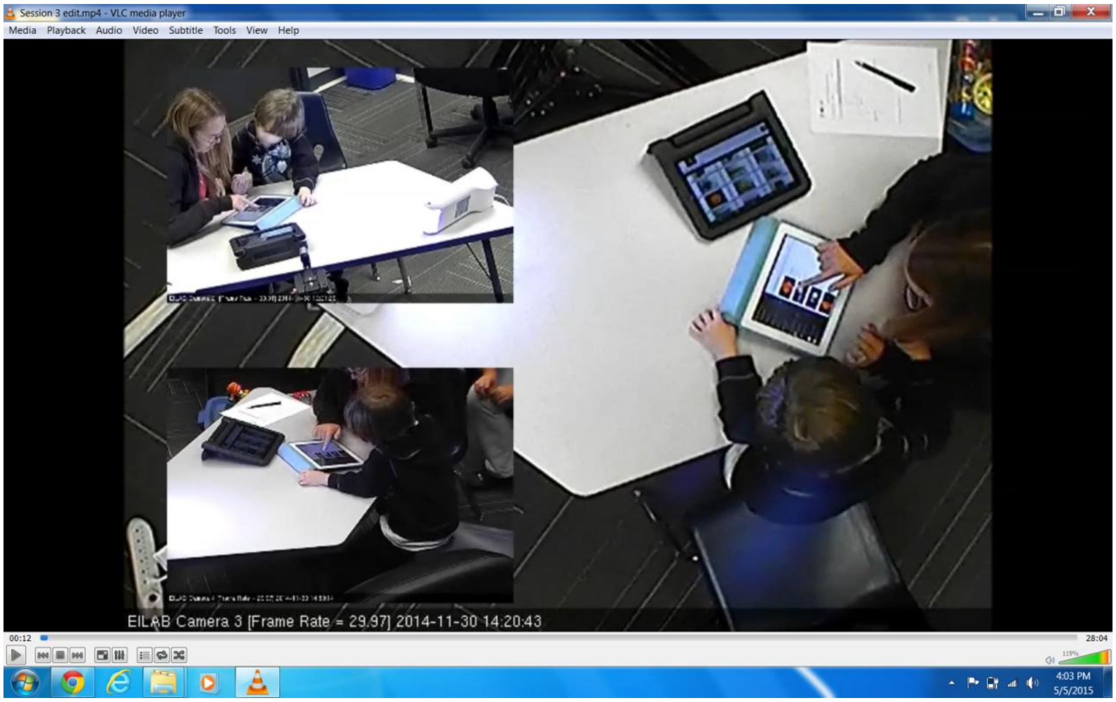


Figure 5 - Screen capture of the synchronously captured video used for analysis

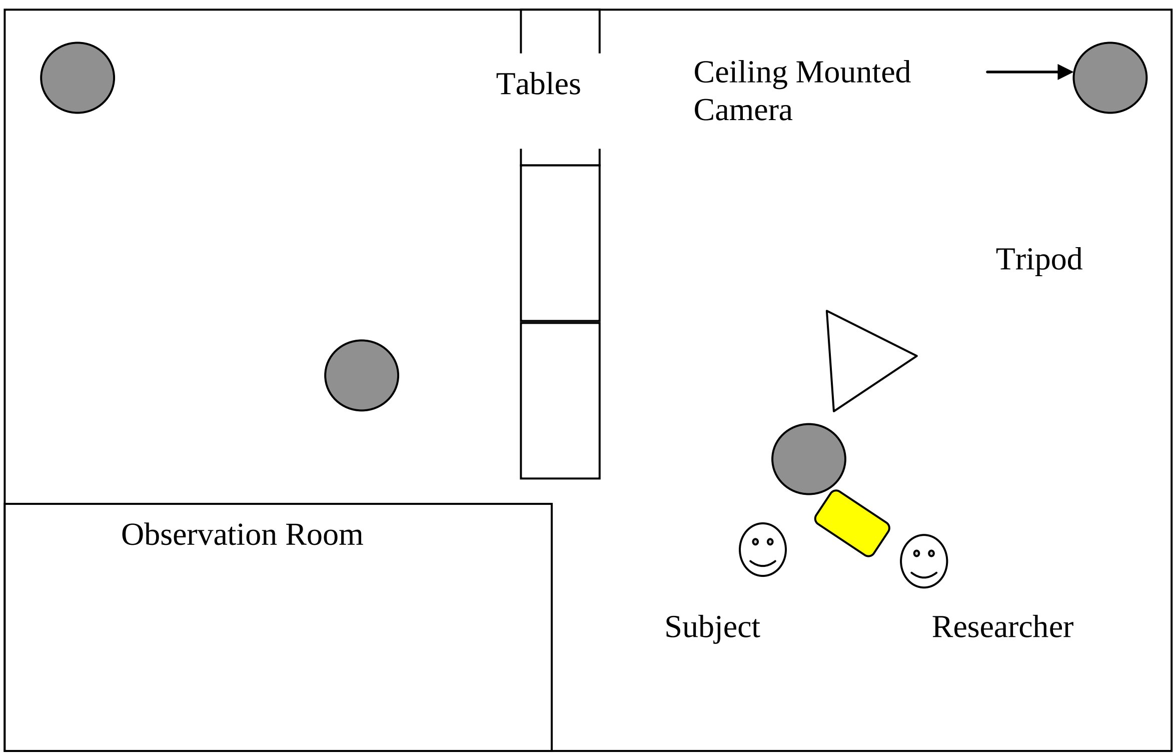


Figure 6 – Floor Plan of the Educational Informatics Lab (EI Lab) used for the current research study.

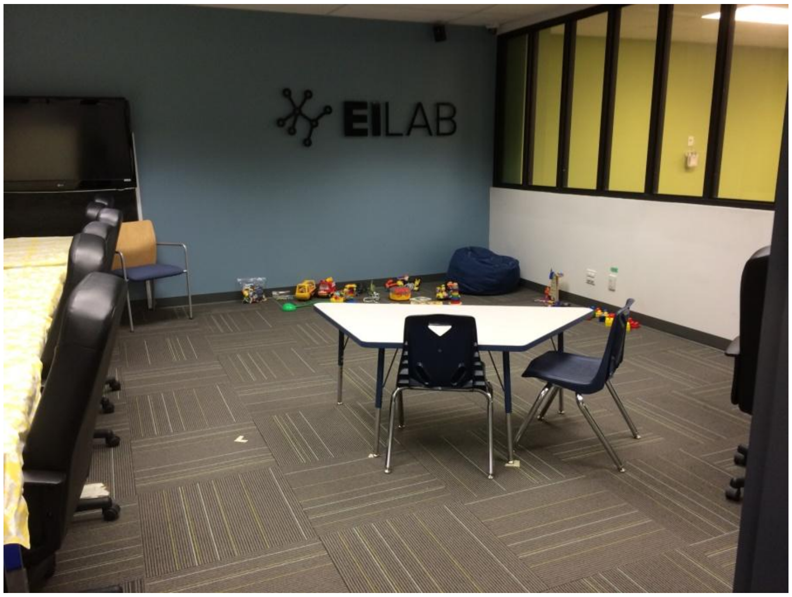


Figure 7 - Photo of the EI Lab set up for the current study

Participants visited the lab with their parents four to five times, with visits averaging 45 minutes each over the course of 2 months. The first visit consisted of an intake interview during which consent forms and details of the study were shared with the participant's parent/guardian. If they chose to participate in the study, a Parent Intake Interview was then conducted which contained questions selected from the Vineland Adaptive Behaviour Scale (2005) in specific areas and supplemented with questions specific to the use of technology and preferences of the child (Sparrow, Cicchetti & Balla, 2005). (See Parent Intake Interview) At the end of the first visit a schedule was set for upcoming visits. The second visit to the lab consisted of a teaching phase, during which the use of the app to request preferred items was demonstrated to the child. Visits three to five had the child using the device to request items, while the user interface variables of button size and array size were manipulated. (See Procedure) Parents remained in the room with their children at all times during the study, taking breaks as needed to decrease stress levels for the children.

Research Design

A case study design with 3 participants was used for this research. This design allows researchers to make in-depth observations of each subject while examining the impact of the independent variable on one or more dependent variables (Kratochwill & Levin, 2014; Merriam, 1998). This design utilizes each subject as their own control, tracking their responses over time and different variables allowing for conclusions to be made based on the performance of individual participants. This design is commonly used in research with individuals with autism spectrum disorder due to significant variation of physical, intellectual and behaviour characteristics between individuals (Arthanat, Curtin & Knotak, 2013).

Specifically, an exploratory study was conducted to compare the interaction of the participants with the augmentative communication app across different user interface settings involving array and button size.

Participants

Three children were recruited from a treatment centre that provides a variety of therapy services to children with developmental disabilities. During the parent interview process it was reported that all three participants met the following criteria: (a) diagnosis of autism spectrum disorder, (b) between 3 and 6 years of age, (c) use less than 10 words regularly, (d) able to sit for 5-10 minutes, and (e) sufficient motor and visual skills to operate the tablet based AAC communication system. All children involved in the study were found to be familiar with touch screen, tablet based technology and were regularly exposed tablets them for leisure activities.

Caleb was a 4-year old male diagnosed with autism spectrum disorder and sensory processing disorder. His scores were moderate across all areas of the parent survey (See Table 1). He made some spontaneous sounds during sessions, but no recognizable words. Caleb was introduced to PECS at the commencement of the study by a Speech and Language Pathologist and was said by his mother to have rapidly picked up on the system.

Tebey was a 4 year old boy diagnosed with autism spectrum disorder. His scores from the parent survey showed a low adaptive level across Receptive Language, Expressive Language and Literacy domains (See Table 1). His score in Motor Skills was moderate. Tebey showed some spontaneous language asking for ‘apple’ to indicate he wanted juice and ‘bye-bye’ when he wanted to be finished. His parents indicated that he would be starting to use PECS soon, but had not yet started.

Andre was a 4.5 year old boy diagnosed with autism spectrum disorder. His scores from the parent survey were in the high range for the Receptive Language, Motor Skills and Literacy areas. Andre's Expressive Language score was low and he showed very limited spontaneous language during sessions. His mother reported that he has been successfully using PECs for over 2 years to communicate his needs at home, school and in therapy sessions. Andre is also in the early stages of being introduced to the Unity 84 system, which is an assistive device that utilizes the principals of core language and will allow him to use more complex language.

Table 1 - *Summary of Scores from Parent Intake Interview*. This data summarizes the information collected during the parent intake interview (Appendix $$$). The highest possible score for each subsection is located in the bottom row.

	Receptive Language	Expressive Language	Motor Skills	Literacy
Caleb	3.5 – moderate	3 – low	4.5 – moderate	0 – low
Tebey	2 – low	1.5 – low	4.5 – moderate	0 – low
Andre	7 - high	4 - moderate	6 - high	3 - moderate
Highest Possible Score in Section	7	9	7	4

Parent Interview Survey

A parent interview was implemented during the first session using an adapted version of the Vineland Adaptive Behaviour Scale, Second Edition (2005) for the purpose of rating the participants on motor skills, expressive and receptive language skills, and literacy (Sparrow, Cicchetti & Balla, 2005). Questions were selected from the scale to use in the interview form that were age appropriate and relevant to the study. Parents were read a statement such as “Does your child listen to instructions (e.g. go sit down)?” They were asked to rate the statement by saying usually, sometimes or never, a visual was placed on the table to remind them of their choices. (See Appendix D for full Parent Interview Form) There were varying numbers of questions for each domain (Table 2). Questions that were answered as ‘Usually’ received a score of 1 point, ‘Sometimes’ received 0.5 points and ‘Never’ received 0 points. Totals were then calculated for each child, for each domain. Criteria were set for a low, moderate or high rating for each domain based on the number of questions answered (Table 2).

Table 2 - Breakdown of Parent Interview Form – The number of questions and rating scale for each developmental domain in the Parent Interview Form adapted from the Vineland Adaptive Behaviour Scale (Sparrow et al, 2005).

		Rating Scale		
Developmental Domain	Number of Questions	Low	Moderate	High
Receptive Language	7	0-2	3-5	6-7
Expressive Language	9	0-3	4-6	7-9
Motor Skills	7	0-2	3-5	6-7
Literacy	4	0-1	2-3	4

Additional open-ended questions were also asked which covered familiarity with technology, previous experience with augmentative communication and preferences for toys and snacks (See Appendix D).

Preferred Stimuli

For this procedure it was necessary to determine snacks and toys that the participants would be motivated to request. These items were identified during a two stage stimulus preference assessment. Stage 1 took place during the parent interview, with questions asking about their child's favorite toys and snacks (see Appendix D). From this list, the researcher chose 7 preferred items for each child to present during the direct preference assessment. The Brief Multiple Stimulus without Replacement (B-MSWO) procedure was used for the direct preference assessment at the beginning of each session (Carr, Nicholson & Higbee, 2000; DeLeon & Iwata, 1996). Seven items were placed on the table in random order, and the child was allowed to select one at a time. Items were not replaced after they were selected, allowing the researcher to create a rank order of preferred items. Toys and food items were assessed simultaneously in the same array (See Appendix C for full procedure).

The information gathered during the preference assessment was used to set up the display for each session. The array was modified to present only one preferred item from the child's top 3 selections. All other items presented in the array were neutral items that had to reinforcing value to the child such as a toilet paper roll, fabric bow and large binder clip.

Procedure

The procedure for this study was an adapted format of the Picture Exchange Communication System - Phase 3 similar to the one used in King et al. (2014), however due to beginning our study at Phase 3 a verbal prompt of "What do you want?" was used when presenting the iPad. It was chosen to begin this study at Phase 3 of the PECs protocol, as this is the first phase that requires the discrimination of a picture from an array. A most-to-least prompting strategy was used for the initial teaching session beginning with the highest level of prompting (light physical prompting at the hand to touch the device) and fading to less prompting as the session continued, with all sessions after that utilizing a least-to-most prompting strategy (using the least invasive prompt needed).

The participants, with their parents, visited the lab for four or five 45 minute visits over the course of two months in the autumn of 2014. Visits two to five were video recorded for analysis utilizing ceiling mounted cameras in the EI Lab at UOIT. The researcher conducted a Brief Multiple Stimulus without Replacement (B-MSWO) preference assessment at the beginning of sessions 2-5 (see Appendix B for full procedure and data sheet).

Visit 1: Consent and Intake Interview. The first visit consisted of answering questions, determining eligibility to participate and gaining consent. After the consent process was complete the researcher conducted an interview with the parents of potential participants in the laboratory setting. The child remained in the lab with their parents during the interview. This allowed the child to become accustomed to the setting and decreased anxiety for future visits. Age appropriate toys were provided. The interview was an adapted version of the Vineland Adaptive Behavior Scale, Second Edition (2005) covering information such as motor skills, expressive and receptive language skills and literacy (Sparrow et al., 2005). Questions about familiarity with tablet based technology and preferences such as toys and snacks were also added to supplement the information. Data from the interview was recorded through notes taken by the researcher on the interview guide form (Appendix D).

Visit 2: Introduction to the app/Teaching Trials (1x2 array; button size: 9.9x9.7cm) (See Figure 8). The researcher conducted a Brief Multiple Stimulus without Replacement (B-MSWO) preference assessment to determine the child's preferences (Appendix B). Upon completion, the researcher used the data from the preference test to introduce the child to the app through demonstration and prompting. Prompting took the form of modeling the desired response (model prompt), gesturing to the appropriate button on the app (gestural prompt), light physical guidance of their hand (full physical prompt) or light physical guidance of their wrist (partial physical prompt) to touch the appropriate button on the app. Positive social reinforcement (praise) in addition to access to desired objects or snacks was used to reinforce attempts to use the device.

Procedure for teaching trials:

1. The iPad was placed on table in front of child with Proloquo2Go app open and displaying home screen.
2. The researcher presented a tray to the child that held the 4 most desired items from preference assessment.

3. When child reached towards one item, the researcher directed them to touch the button on the app using Full Physical (5 trials), Partial Physical (5 trials), Gestural (5 trials), No Prompting (remaining trials).
4. When the child had touched the button, they immediately received access to the item for 20 seconds or until consumed (edible items). A timer was used to track access. After a countdown of "3, 2, 1, my turn" the researcher removed the item.
5. The researcher replaced the item on tray and shuffled the items.
6. The researcher continued to the next trial.

Multiple trials were conducted over a 30 minute period, monitoring the subject for frustration and fatigue. Data was collected through audio and video recording for coding after the session, as well as tracking the prompting level required for each successful trial.

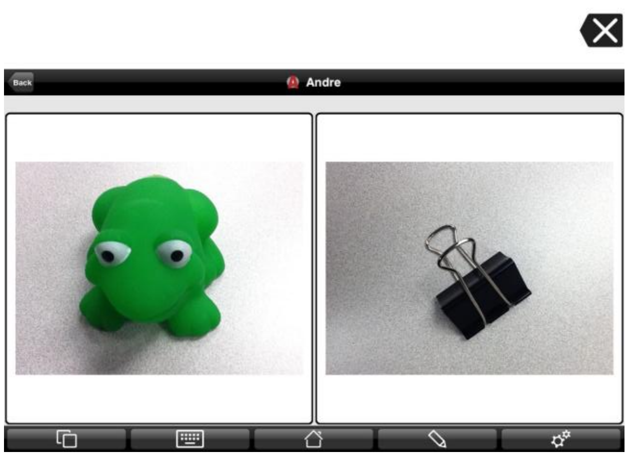


Figure 8 - Screen capture of Proloquo2Go settings for Teaching Trials – 1x2 array

Visit 3: Phase 1: Proloquo2Go Setting 1 - 2 column view (array of 4; button size: 4.9x9.7cm) (See Figure 9). Upon completion of the preference assessment, multiple trials were conducted using the procedure below. Data was collected through audio and video recording for coding after the session (See p.48, Data Analysis).

Procedure for phase trials:

1. The iPad was placed on table in front of child with Proloquo2Go app open and displaying home screen.
2. The researcher presented a tray to child that held the 4 most desired items from preference assessment.
3. When child reached towards one item, the researcher directed them to touch the button on the app using the least intrusive method of prompt. (No Prompt, Model, Gestural or Physical prompt)
4. When the child had touched the button, they immediately received access to the item for 20 seconds or until consumed (edible items). A timer was used to track access. After a countdown of "3, 2, 1, my turn" the researcher removed the item.
5. The researcher replaced the item on tray and shuffled the items.
6. The researcher began next trial.

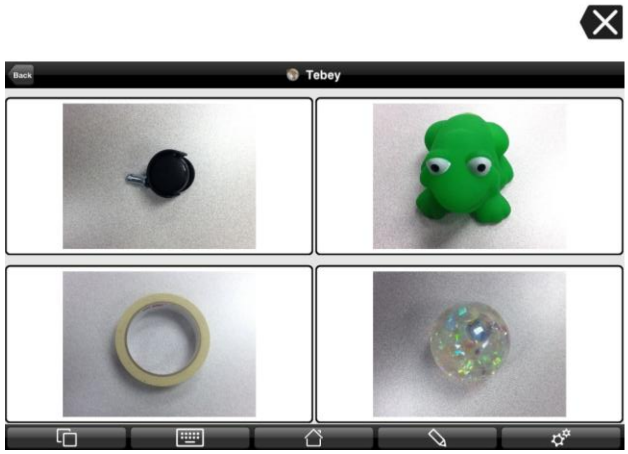


Figure 9 - Screen capture of Proloquo2Go settings for Visit 3 – Phase 1 – 2x2 array

Visit 4: Phase 2: Proloquo2Go Setting 2 - 3 column view (array of 9; button size: 6.4x3.2cm) (See Figure 10). Same procedure as visit 3, with increased access to reinforcing items after each successful use of the device to 30 seconds. Data was collected through audio and video recording for coding after the session (See pg 48, Data Analysis).

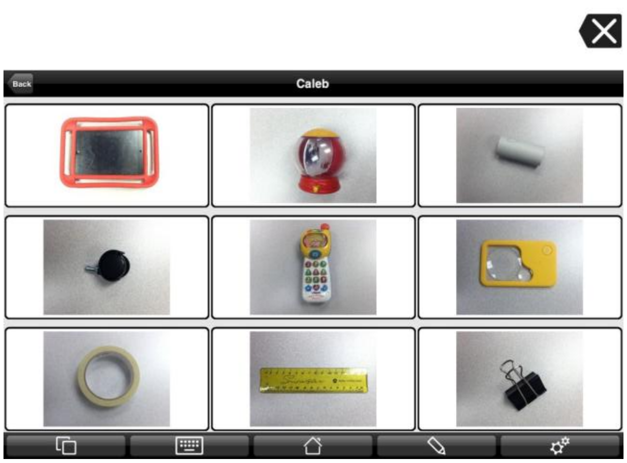


Figure 10 - Screen capture of Proloquo2Go settings for Visit 4 – Phase 2 – 3x3 array

Visit 5: Phase 3: Proloquo2Go Setting 3 - 4 column view (array of 16; button size: 4.8x2.4cm) (See Figure 11). Same procedure as visit 4, with increased access to reinforcing items after each successful use of the device to 1 minute. Data was collected through audio and video recording for coding after the session.

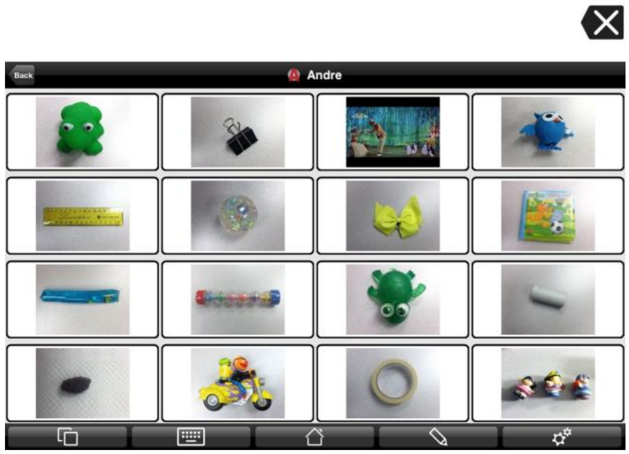


Figure 11 - Screen capture of Proloquo2Go settings for Visit 5 – Phase 3 – 4x4 array

Materials

An iPad 2 equipped with Proloquo2Go was used for all research trials. The iPad was equipped with a protective case and screen protector. Unless otherwise specified, the default settings for Proloquo2Go are used, with the exception of the manipulated settings of button size and array size.

Data Analysis

Video data was collected during sessions 2-5 to analyze for accuracy of using the device across varying user interface settings. All sessions were video recorded from multiple vantage points for further analysis using the Noldus software tools. Noldus' software package, The

Observer XT, allows for the qualitative coding and description of behaviour using video-recorded data that can subsequently be analyzed quantitatively (See Figure 12).

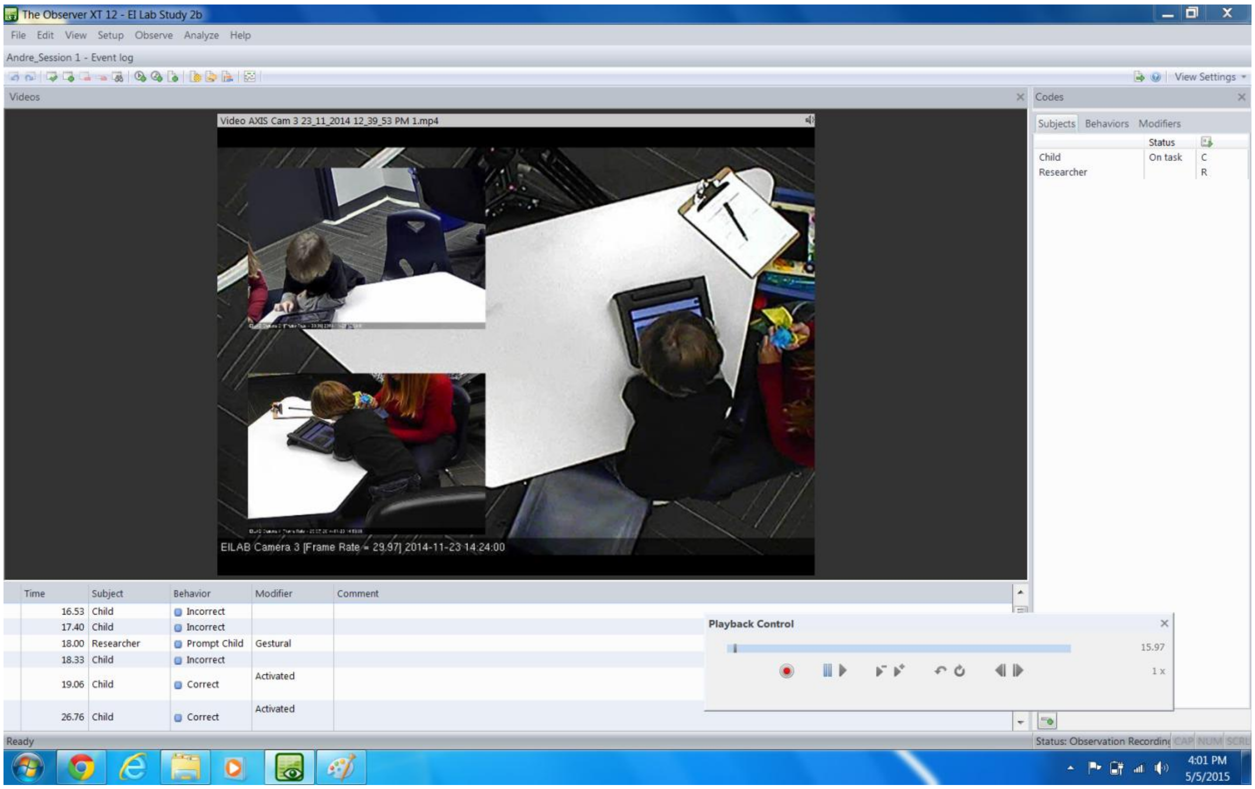


Figure 12 - Screen capture of analysis within The Observer XT

Video was coded, using The Observer XT, for multiple behaviours with modifiers for both the subject and researcher's behaviour (See Table 3). An algorithm was also developed for coding sequences of behaviour as they occurred during sessions. (See Figure 13).

Table 3: *Coding Behaviour Groups and Modifiers*. This table shows the breakdown of behavior groups and modifiers that were used with each subject when coding the video data collected during this study.

Subject	Behaviour Group	Modifiers
Child	1) Touch	
	a) Correct	• Activated • Not Activated
	b) Incorrect/Random	
	2) Attention	
	a) On task b) Off task c) Break	
Researcher	1) Prompt child	• Full physical prompt • Partial physical prompt • Gestural prompt
	2) Assist with device	

Using video-recorded data also allowed for inter-rated reliability measures (comparative coding by more than one researcher). Inter-rater reliability was checked on 16% (50 minutes) of the videos using comparative coding with 1 other researcher currently conducting graduate level research within the Faculty of Education. The graduate student was provided with a 20 minute training session on using The ObserverXT software and shown examples of target behaviours before beginning coding. Inter-rater reliability was found to be at 88% for the 50 minutes of comparative coding completed, when the target behaviours of Correct Selection – Device Activated, Correct Selection – Device Not Activated, Incorrect Selection and Researcher Prompted trials were compared.

It was the initial intention of the researcher to include eye gaze within the data analysis for this study as an initial step in discriminating the correct picture on the iPad screen. However this was not possible due to a couple of factors. Our video angles and quality of picture did not provide enough detail to determine the eye gaze of the participants. It was also noted that irregular eye gaze patterns is a characteristic of individuals with autism spectrum disorder, so even with more detailed video tracking eye gaze would be difficult without the use of specialized equipment (American Psychiatric Association, 2013; National Research Council, 2001).

The Noldus software tool, FaceReader is used to analyze facial expressions. It was initially planned to use this for analysis during this study, however this did not prove to be feasible due to the active nature of the participants. The software requires an image in which the person's face is centered within the picture without much lateral movement. Due to the age and disorder of our participants this level of video capture was not possible.

Algorithm. During data analysis, repeating patterns in the data began to emerge which lead to the development of an algorithm for analysis. The first pattern to emerge was that often the children would be successful at selecting the correct icon and touching the device, but the device would not react to the touch. This would often be quickly followed by another touch of the icon, when the children noticed that the voice output was not activated. Another pattern that emerged was random touching, in which the child would not look at the device to begin the process and would touch any icon often resulting in the choice of an undesired item. From these observations, some basic steps were isolated that often lead to successful activation of the device; the child must look at the device, touch the device, the device must react and then the child would receive the desired item. To begin tracking these patterns, instead of just isolated events an algorithm was created that showed the steps that lead to each outcome (See Figure 13).

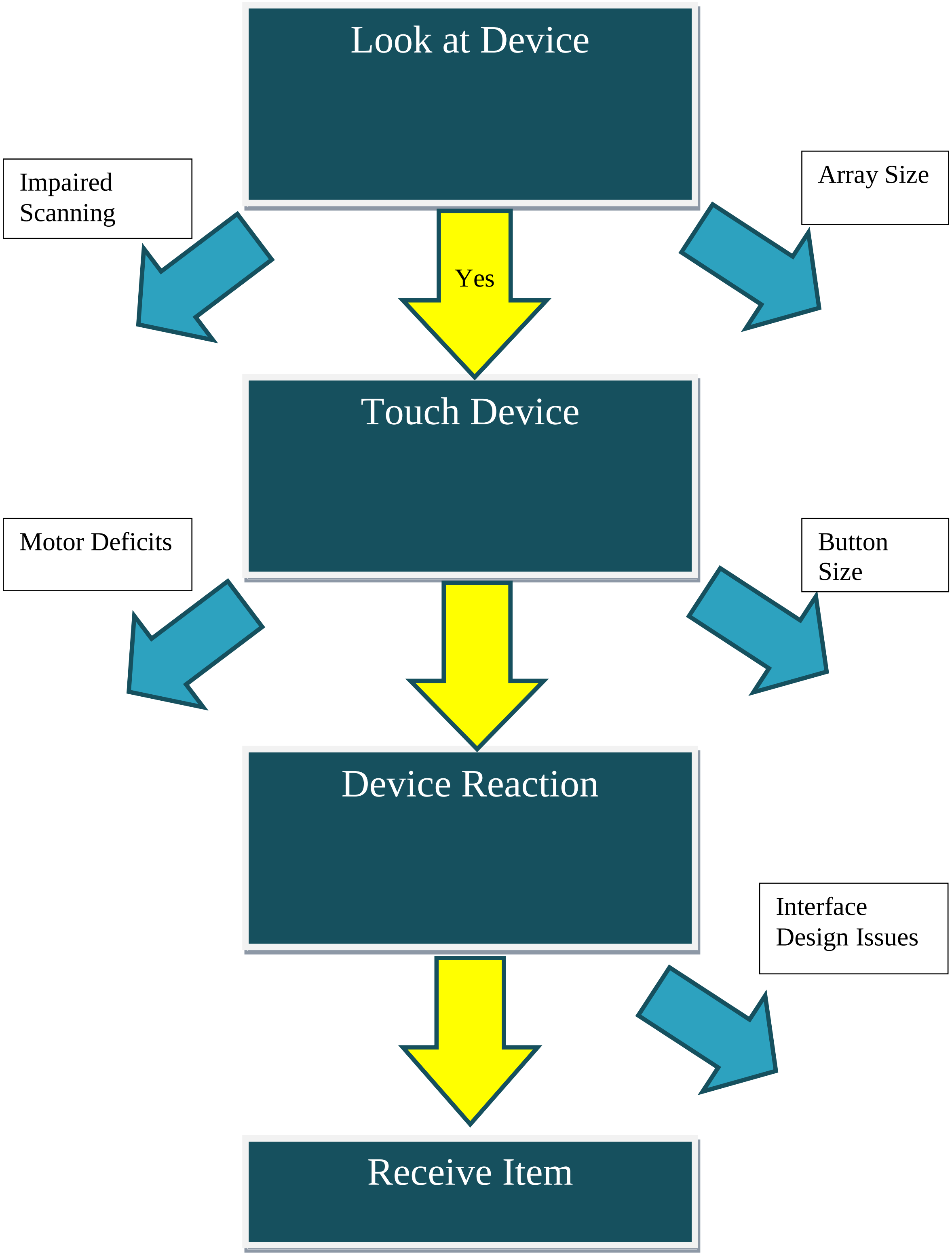


Figure 13: Algorithm for Data Analysis – The figure shows the sequence of steps utilized in creating the algorithm for data analysis.

The first step in our sequence was to look at the device. This step allowed the child to choose which icon they would touch on the iPad, rather than randomly selecting any icon. Barriers to successful completion of this step could come from the user or the user interface. The user may have difficulty with scanning multiple icons that are presented to them, commonly referred to as impaired scanning. The user interface may also exacerbate this type of barrier by having too many items in the array. If the look step was successful, participants would then move to touching the device.

The second step in our sequence is to touch the device. This step is required for activating tablet based interfaces which utilize touch-screen input. One of the barriers to the successful use of tablets for individuals with autism spectrum disorder is motor skill deficits. These motor skill deficits may cause difficulty with precise fine motor movements that are required to activate the touch-screen. The user-interface can aid or impair this issue depending on the button size that is presented on the screen. Incorrect button size for a user may impede their ability to touch the device and create the device reaction.

The third step in our sequence is device reaction. Device reaction on a touch screen device, such as the iPad used in this study, involves the activation of the touch screen in response to the child's touch of the device. Within Proloquo2Go the device needs to react to the touch of the participant by activating the voice output for the participant to receive their desired item. Activations not occurring at this point in the sequence were thought to be issues with the user interface design or the functionality of the iPad itself rather than a skill deficit on the part of the child.

The shortest, most efficient path to receiving a desired item was to look at the device, touch the correct button and the device would react. Often the path would diverge along the way, requiring assistance from the researcher. A divergence at the 'Look' stage would result in a gestural prompt to the device. A divergence at the 'Touch' stage would result in a gestural prompt or a physical prompt to assist them to touch the device as needed. When the device would not activate, the researcher would prompt if needed however it was noted that often the children would attempt to touch the device again to activate it. The earlier in the sequence the divergence from the most efficient path occurred, the more likely it was for the sequence to not be successful.

Findings

This chapter will outline data collected during this study. We will examine the 3 participants and the results of their sessions individually covering their rate of responding, response to the three phases of the study, performance according to our analysis algorithm and overall ability to use the device for communication. Parent interviews were done as part of the intake process to assess each participant's abilities in receptive language, expressive language, motor skills, literacy, and familiarity with technology (Table 1, pg 36). This interview informed the researcher about the children's abilities and also allowed for some individualization of the research process in regards to prompting and progression of phases.

This chapter presents the data for each child as a case study. This approach was selected as each child in our study presented with a unique set of skills and experiences leading to a diverse group of subjects. This approach is commonly used in research with individuals with autism spectrum disorder, as variation is often seen in physical, intellectual and behavioural characteristics due to the spectrum nature of the diagnosis (Arthanat et al., 2013). For example Caleb and Andre had both experienced behaviour interventions in the past, influencing their ability to participate in the study and comply with instructions given by the researcher. This could lead to confounding differences in their data, were it compared to Tebey's data. All three children had been exposed to touch-based tablet technology in the past and were familiar with its use, however two of the subjects had been given free access to the devices and one had restricted access to only learning games. All three subjects differed in the measure of receptive language delivered during the parent interview, with one rating high, one moderate and one low (See Table 1, pg 36). These differences between subjects all lead to the treatment of the data in a case study format.

As described in the previous chapter, each session with the participants was both audio and video recorded synchronously with multiple cameras to capture each event from a variety of points of view, including a detailed view of the actual device. From the combined recordings, using NOLDUS ObserverXT, all the interactions were coded for multiple behaviours.

For the purposes of coding and comparison, responses were classified into:

- Correct – device activated: In this response, the child would select the icon depicting the desired item on the screen by touching it and activating the voice output function. During each phase, one desired item would be represented by an icon on the screen, alongside 3 neutral items. For example, during session one for Caleb the screen showed one icon of the Sesame Street Toy and one with a picture of a binder clip. To meet criteria for this code, Caleb chose the Sesame Street Toy icon from the array and activated the voice output resulting in the device saying “Sesame Street Toy”.
- Correct – device not activated: For this response, the child would follow the steps as described in correct – device activated, however the voice output function would not activate. This result is attributed to device error or the child not touching the device correctly, rather than an incorrect selection. During session one, Andre would be presented with the screen showing an icon for Mary Poppins and a gift bow. He would touch the Mary Poppins icon, and the device would not activate the voice output.
- Incorrect (or random touch): For this response the child would select an icon on the screen that represented a neutral item. During session one, Tebey was

presented with the iPad showing the fish bowl and a toilet paper roll. On trials when he selected the toilet paper roll from the array, they were coded as incorrect.

- Prompted trials: This code was used for any trial in which the researcher needed to assist the child in touching the correct icon or to activate the device. Prompting took the form of pointing (gestural), physical guidance from the wrist (partial physical prompt) or gentle hand over hand guidance (full physical). During most trials a maximum of one prompt was used, however during some of Tebey's trials during sessions 3 and 4 he required a gestural prompt to attend to the screen and then a physical prompt to touch the icon. In this case 2 prompted trials were counted.

The breakdown of each of these responses is provided per subject for analysis looking at frequency of responses per session, and clusters of responses as indications of usability of the app during each phase of the study. Each time a child visited the lab, it was counted as a session. During each session the child would use the device with a different set of user interface characteristics, depending on the current phase of the study. During Caleb's session 2, he participated in phase 1 of the study during which the app was set for a 2x2 array to display. Each time that the device was presented to the child to request an item was a trial, with their reaction counted as a response. Occasionally there would be a quick pattern of responses, which we classified as sequences.

The following list summarizes the terminology used in this chapter:

- *Session*: Each visit that the child made to the lab.

- *Phase*: The phase of the experiment that was being conducted during each visit during which variables were manipulated. For example, in Phase 1 the app displayed a 2x2 array and in Phase 2 this was increased to a 3x3 array.
- *Trial*: Each time the device was presented and the child was asked “What do you want?”
- *Response*: The response that the child made to each trial.
- *Sequence of Responses (Patterns*): A combination of responses that quickly followed each other creating clusters of responses.
- *Prompted Trial*: The child needed assistance from the researcher to complete the response.

The same basic structure was followed in presenting each child’s data, first presenting a basic introduction with information about time on task and preferred items. Next we reviewed rate of responding per session and factors that may have influenced this rate. We then presented information on prompted trials with the frequency of prompting (researcher intervention) needed and the form of prompting (hand-over-hand vs. pointing) used to assist the child in successfully activate the device. Correct trials were then examined, looking at the proportion of total trials per session that were correct and then breaking those trials down into patterns that fit the algorithm for analysis (Figure 13, pg 46).

Caleb

Caleb was a willing and eager individual throughout his participation in the study. He stayed on task for the majority of our time in the lab across all sessions, requiring only short breaks with successful transitions back to ‘work’. During session two, he was on task for 98% of our session with 2% of the time needed for breaks. He was motivated to request multiple items including: his iPad, a Sesame Street Toy, various light-up sensory toys and YouTube videos. Caleb consistently responded to instructions of “What do you want?” by looking at the device, choosing an icon and pushing the button. His rate of responding stayed consistent across all sessions at approximately 3 responses per minute, with the exception of session 4. During session 4/Phase 3 he received extra time with his reinforcing object due to researcher perceived increase of difficulty in scanning and finding the chosen icon in a 4x4 array which resulted in fewer overall responses (see Table 4).

Table 4 - *Rate of Responding and Total Frequency of Responses for Caleb*

Session Details	Response	Responses per Minute	Total Frequency of Responses
Session 1	Correct - Activated	2.43	53
	Correct - Not Activated	0.64	14
Teaching: Array 1x2	Incorrect	0.23	5
	Total Responses		72
Duration: 22 minutes	Prompted	1.19	26
Session 2	Correct - Activated	2.33	80
	Correct - Not Activated	0.46	16
Phase 1: Array 2x2	Incorrect	0.18	6
	Total Responses		102
Duration: 34 minutes	Prompted	0.9	3
Session 3	Correct - Activated	2.48	36
	Correct - Not Activated	0.24	6
Phase 2: Array 3x3	Incorrect	0.12	3
	Total Responses		45
Duration: 25 minutes	Prompted	0	0
Session 4	Correct - Activated	1.37	31
	Correct - Not Activated	0.16	4
Phase 3: Array 4x4	Incorrect	0	0
	Total Responses		31
Duration: 22 minutes	Prompted	0	0

During session one, Caleb required researcher intervention (prompting) on approximately one-third of the total trials conducted (See Table 4 and Figure 14). This took the form of full physical prompting, which involved hand over hand prompting to touch the screen, and later gestural prompting during which the researcher would point to the desired icon on the screen. This dropped to needing prompting three times in over 100 trials in session two, always with a gestural prompt, and zero assistance in sessions 3 and 4. There was also a decrease in the number of incorrect selections as Caleb's sessions progressed.

The number of correct trials, as a proportion of the total trials, increased through the sessions. In session one Caleb chose the correct icon on ¾ of the total trials. This increased to correct selections on 4/5 of the trials in sessions two and three, and all of the trials in session four (see figure 14). The total number of trials that took place per session decreased across phases two and three (See Table 4 and Figure 14). This occurred because of the perceived increase in difficulty for the child to locate and select the correct icon in a larger array on the display. The child was also allowed access to the preferred item longer, once they had found the icon and activated the device. The researcher adapted the procedure at this stage to each child, their abilities and frustration level.

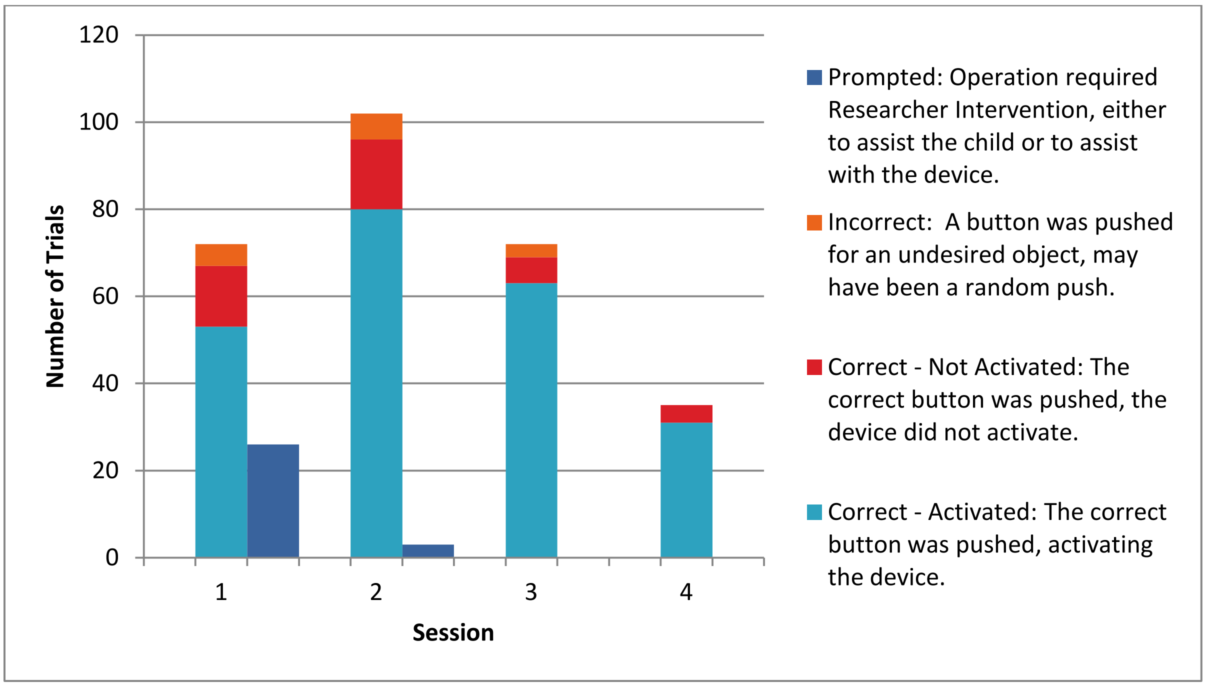


Figure 14 - Proportion of Trials by Session for Caleb: The proportion of trials per session that required prompting, or resulted in the touching the incorrect button, correct button with activation of the device or correct button without activation of the device.

During session one for Caleb, the researcher noted the pattern of Caleb selecting the correct icon and touching it with no device activation. On the very first trial that was run with Caleb, the researcher used a hand-over-hand prompt to select the icon for the Sesame Street toy that Caleb had just been playing with. After grasping the child's hand and placing it upon the correct icon, the device did not activate. The researcher immediately prompted the child to retouch the screen which resulted in activation of the device. This series of events, resulting in no activation, was then coded for and added to the data analysis. During sessions one and two, the number of times that this pattern occurred was somewhat consistent (14 and 16 times, respectively), the number of occurrences dropped in session three (6 times) and session four (4 times), showing that there may have been some training as to how to activate the device effectively. Figure 14 provides a visual representation of the proportion of each response by session for Caleb.

An algorithm was developed for coding responses when looking at specific sequences of responses within our research sessions (See Figure 13, pg 46). Repeating sequences were given a code which was used to analyze each session, the visualization tool within The ObserverXT was used to visualize these sequences of behaviour (See Figure 15). Within the data across Caleb's 4 sessions in the lab, a pattern began to emerge. A large number of the responses were independent and accurately activated the device after our first session, regardless of the changes in button size and array size (See Table 5, Code B). Through all of his sessions we also noted a continuation of the pattern noted at the beginning of his first session, in which he would touch the correct icon on the screen and it would not activate. However, often he would immediately and independently touch the device again realizing that the voice output had not been activated and usually activating it on the second push (See Table 5, Code D). This response was prompted 3 times

(Code E) during the first session, while teaching the student to use the device and he was able to use it independently for all remaining sessions.

Figure 15 - Visualization from The ObserverXT: Caleb Session One. This figure is a screenshot of the visualization tool in ObserverXT used to analyze Caleb Session One. The letter codes at the top of each vertical bar correspond with the codes in Table 5. Full timelines of each session available in Appendix G.

Table 5 - *Algorithm Analysis by Session for Caleb*

Code	Sequence	Session 1	Session 2	Session 3	Session 4
A	Touch → Device not activated (independent)	0	0	0	0
B	Touch → Device Activated (Independent)	29	61	53	25
C	Touch → Incorrect (Independent)	3	4	2	0
D	Touch → Device not activated, Touch → Device Activated (Independent)	8	12	5	4
E	Touch → Device not activated, Touch → Device Activated (Researcher Intervention)	3	0	0	0
F	Touch →Device Activated (Prompted)	10	3	0	0
G	Touch → Device not activated (prompted)	0	0	0	0

Overall, Caleb was able to use the device effectively for communication across all 4 phases of the study. The decrease in button size and increase in array did not appear to decrease his ability to locate and select the icon for his preferred items.

Tebey

Tebey was the second participant in this study. He had difficulty sitting still and was often off task during sessions. This difficulty increased as sessions progressed, requiring the researcher to adapt the protocol for his sessions by repeating phase 2 during session 4. During session two, Tebey was on task for 48% of our session, with 37% of the time off task and 14% on break. He was motivated to request juice, a toy fish bowl and sensory toys, but would also repetitively request items that he then would appear to not want to play with or would throw. For the purposes of data analysis, we counted all purposeful selections (that were not non-preferred neutral items) as correct icon selections. He also had difficulty giving up items to either the researcher or his mother and would try to grab the device rather than using it for communication even when prompted by the researcher. Due to performance issues in session 3, the device remained at a 3x3 array for session 4 rather than increasing difficulty.

Tebey was inconsistent in responding to the instruction of “What do you want?”, while being presented with the device. His rate of responding was highest during session one, decreased by half during session two and to one third of the original rate during sessions three and four (See Table 6). This correlated with an increase in off-task behaviour and resistance to participation as sessions continued.

Table 6 - *Rate of Responding and Total Frequency of Responses for Tebey*

Session Details	Response	Responses per Minute	Total Frequency of Responses
Session 1	Correct - Activated	3.32	50
	Correct - Not Activated	1.82	27
Teaching: Array 1x2	Incorrect	1.08	16
	Total Responses		93
Duration: 14 minutes (on task)			
	Prompted	1.34	20
Session 2	Correct - Activated	2.11	69
	Correct - Not Activated	1.22	40
Phase 1: Array 2x2	Incorrect	0.12	4
	Total Responses		114
Duration: 32 minutes	Prompted	2.34	77
Session 3	Correct - Activated	1.3	42
	Correct - Not Activated	0.37	12
Phase 2: Array 3x3	Incorrect	0.46	15
	Total Responses		69
Duration: 32 minutes	Prompted	1.27	41
Session 4	Correct - Activated	0.86	22
	Correct - Not Activated	0.89	23
Phase 2 (repeat): Array 3x3*	Incorrect	0.35	9
	Total Responses		54
Duration: 26 minutes	Prompted	2.35	61

*Deviation from planned methodology due to performance during sessions 3 and 4
Note: Child became less compliant and more behavioural as sessions progressed

During session one, Tebey required researcher intervention (prompting) on approximately one-fifth of the total trials conducted (see Table 6 and Figure 16). This took the form of full physical prompting (hand over hand) to touch the screen and gestural prompting (pointing to the screen). The rate of prompting needed increased across the next session to needing prompting on approximately two-thirds of the trials in session two. Session three required slightly less prompted trials than session two at approximately three-fifths of the total trials prompted. A large increase in prompted trials was recorded in session four, during which there were more prompts delivered than total trials (See Table 8 and Figure 16). This occurred as the researcher would sometimes deliver a gestural prompt to the device and then also need to use a physical prompt (hand-over-hand) to have the child touch the device (See Figure 17). These were counted as separate prompts.

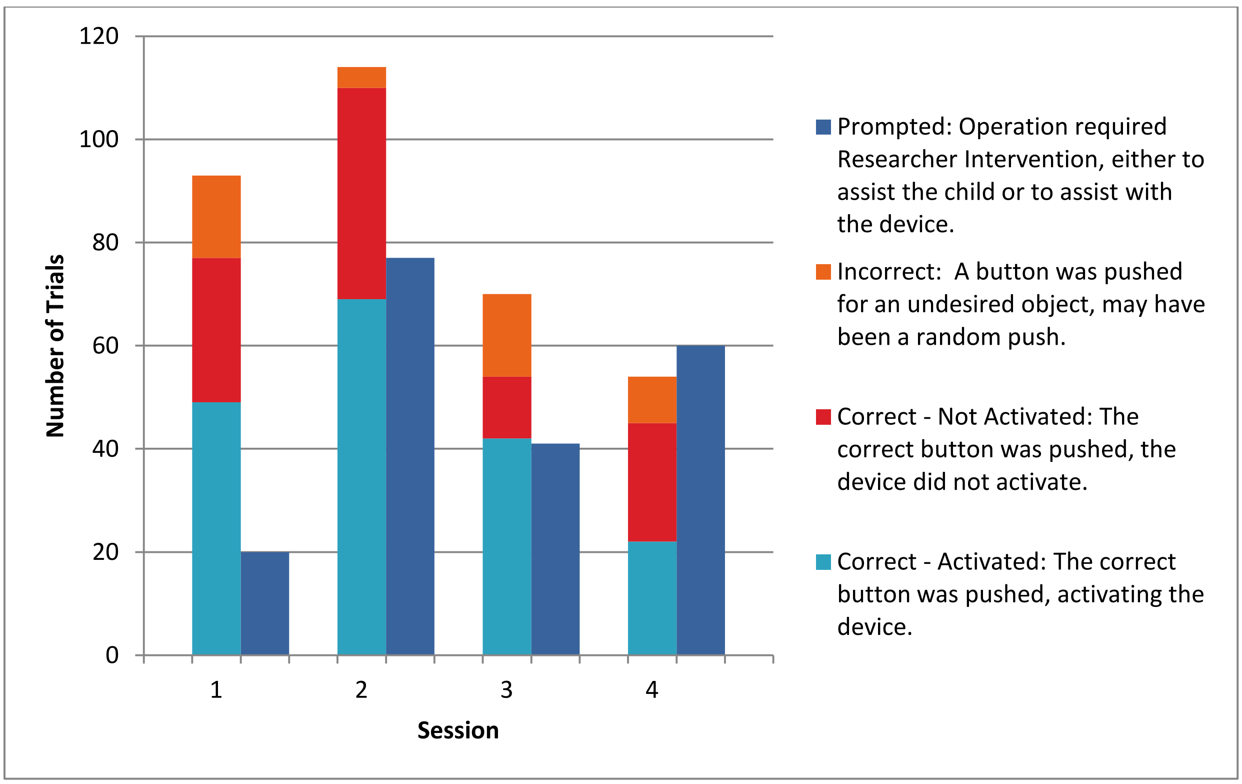


Figure 16 - Proportion of Trials by Session for Tebey: The proportion of trials per session that required prompting, or resulted in the touching the incorrect button, correct button with activation of the device or correct button without activation of the device.

Figure 17 - Visualization of Tebey – Session 4. This figure is a screenshot of the visualization tool in ObserverXT used to analyze Tebey Session Two with 1 minute time settings. This screenshot reflects multiple prompts needed for the child to engage in one response.

The number of correct trials, as a proportion of the total trials was quite variable when examining Tebey's data (See Figure 16). During session one Tebey selected the correct icon on approximately 8/10 trials. This number increased to 9.5/10 trials in session two, however the rate of researcher prompting also went up considerably. This increase in prompting as a proportion of total trials was also seen across sessions three and four, making overall correct selections not an accurate reflection of usage of the device for Tebey. The researcher intervention (prompting) may have been responsible for most of the correct selections during session three and all of the correct selections during session four.

The algorithm was also used to code data from Tebey's sessions. However it was discovered during analysis that the visualization from ObserverXT time settings were too broad for detecting Tebey's rapid movements during sessions. The visualizations were re-generated using a time setting of 1 minute from the previous 30 minute setting (See Figure 18). Table 7 breaks down the data for analysis using the algorithm, and allows for a more clear picture of accurate selections. During sessions one and two, the number of correct and independent selections (Code B) stayed relatively steady at 37 and 33 selections respectively (See Table 7). The rate of independent correct selections dropped to 25 in session three and 5 in session four.

The phase of the study was not changed and settings on the device were kept to a 3x3 array for both sessions three and four due to performance issues during session three. Therefore it is likely that this decrease in independent correct selections during session four is the result of a lack participation in the task and an increase in off-task behaviour. The large percentage of time off task can be seen in the visualization of Session 2 data (Figure 18).

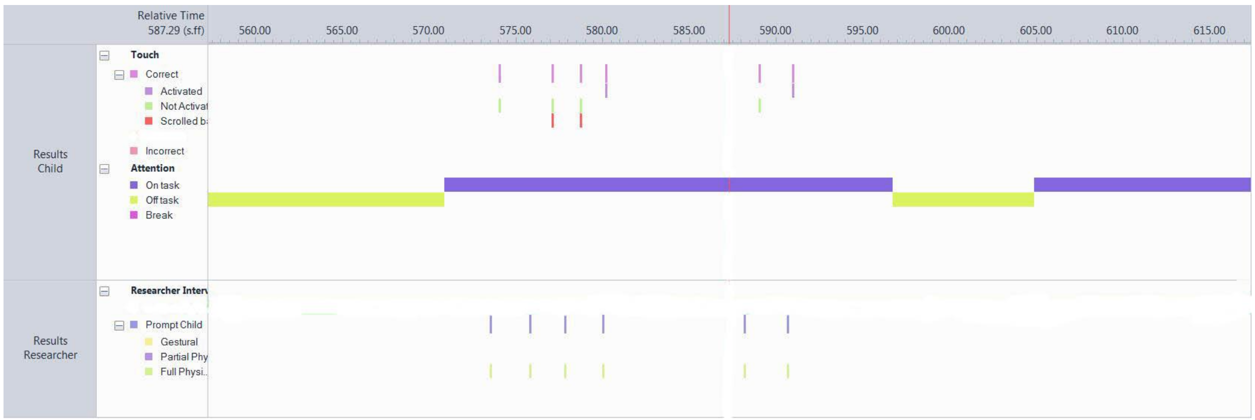


Figure 18 - Visualization of Tebey – Session 2 Data. This figure is a screenshot of the visualization tool in ObserverXT used to analyze Tebey Session Two with 1 minute time settings.

Table 7 - *Algorithm Analysis by Session for Tebey*

Code	Sequence	Session 1	Session 2	Session 3	Session 4
A	Touch → Device not activated (independent)	15	12	5	6
B	Touch → Device Activated (Independent)	37	33	25	5
C	Touch → Incorrect (Independent)	13	4	16	9
D	Touch → Device not activated, Touch → Device Activated (Independent)	5	12	4	2
E	Touch → Device not activated, Touch → Device Activated (Researcher Intervention)	0	6	1	6
F	Touch →Device Activated (Prompted)	3	15	11	8
G	Touch → Device not activated (prompted)	2	11	2	9

Tebey showed a similar pattern to using the device as Caleb and Andre, in touching the correct icon and it not activating (See Table 7, Code A). This was seen as early as the third response of session one and continued to appear through all sessions. During this first occurrence and all occurrences during session one, Tebey was able to independently re-touch the device and activate the voice output successfully (See Table 7, Code D). This pattern of independently re-touching the device was maintained during all sessions, however Tebey also required researcher intervention to complete the sequence on a number of trials during sessions two, three and four (See Table 7, Code E).

Tebey showed a high level of correct selections during sessions one and two, but this dropped rapidly during sessions three and four. It is not possible to conclude that this pattern was seen due to the change in button and array size, as it also correlated with a decrease in participation and increase in off-task behaviour. Proloquo2Go did not appear to be an effective communication tool for Tebey. However, there are multiple factors involved. Unlike the other participants in the study, Tebey had never received any targeted learning instruction such as ABA (applied behaviour analysis) or behaviour therapy. His mother communicated that demands on him in his current school setting (junior kindergarten) were very low and he was attending school on a modified schedule due to behaviour issues and lack of individualized attention. She also indicated that she had difficulty controlling his outbursts. Any one of these factors could impact Tebey's ability to participate in the study. In hindsight, Tebey may not have met the inclusion criteria that required children to be able to sit and attend for a 5 minute period but provides diversity needed within the sample, as educators and professionals are often presented with children with autism spectrum disorder with no previous intervention history.

Andre

Andre was an eager participant throughout his participation in the study and seemed motivated to use the iPad. He stayed on task for the majority of our time in the lab across all sessions, requiring only short breaks with successful transitions back to ‘work. During session two, Andre was on task for 81% of our session, with 15% of time on breaks and 2% of time off task. He was motivated to request multiple YouTube videos (Mary Poppins), a Sesame Street Toy, and various light up sensory toys.

Andre consistently responded to instructions of “What do you want?” by looking at the device, choosing an icon and pushing the button. His rate of responding varied between 2.7 and 3.5 responses per minute (See Table 8). Andre was able to quickly learn the basic functions of the device, so Session 1 was cut short at 13 minutes, to accommodate his family’s scheduling. As a result of this modification the times for each session were quite variable. Variable reinforcement was also used for Andre, when he independently used the device or selected the icon from a larger display to request a video or toy he would receive longer access to that item due to a researcher perceived increase in the difficulty of the task. This resulted in significant variation in the number of trials conducted during each session.

Table 8 - *Rate of Responding and Total Frequency of Responses for Andre*

Session Details	Response	Responses per Minute	Total Frequency of Responses
Session 1	Correct - Activated	2.40	31
	Correct - Not Activated	0.31	3
Teaching: Array 1x2	Incorrect	0.62	8
	Total Responses		42
Duration: 13 minutes	Prompted	0.23	3
Session 2	Correct - Activated	1.90	66
	Correct - Not Activated	0.63	22
Phase 1: Array 2x2	Incorrect	0.05	2
	Total Responses		90
Duration: 35 minutes	Prompted	0.14	5
Session 3	Correct - Activated	2.55	71
	Correct - Not Activated	0.22	6
Phase 2: Array 3x3	Incorrect	0.14	4
	Total Responses		81
Duration: 28 minutes	Prompted	0.07	2
Session 4	Correct - Activated	3.18	58
	Correct - Not Activated	0.16	3
Phase 3: Array 4x4	Incorrect	0.05	1
	Total Responses		62
Duration: 18 minutes	Prompted	0.05	1

During session one Andre required researcher prompting with a gestural prompt to the correct icon on the first 2 trials and one later trial out of 43 that were conducted (See Table 8 and Figure 19). This stayed consistent through session two when he needed prompting on 5 trials out of 90 that were conducted. During session three Andre only needed two gestural prompts and one gestural prompt in session 4. The prompting during sessions three and four was mostly needed to redirect Andre back to use the device rather than pointing at the object he wanted.

There was a decrease in the number of incorrect icon selections across sessions, with a slight increase during session three (See Figure 19).

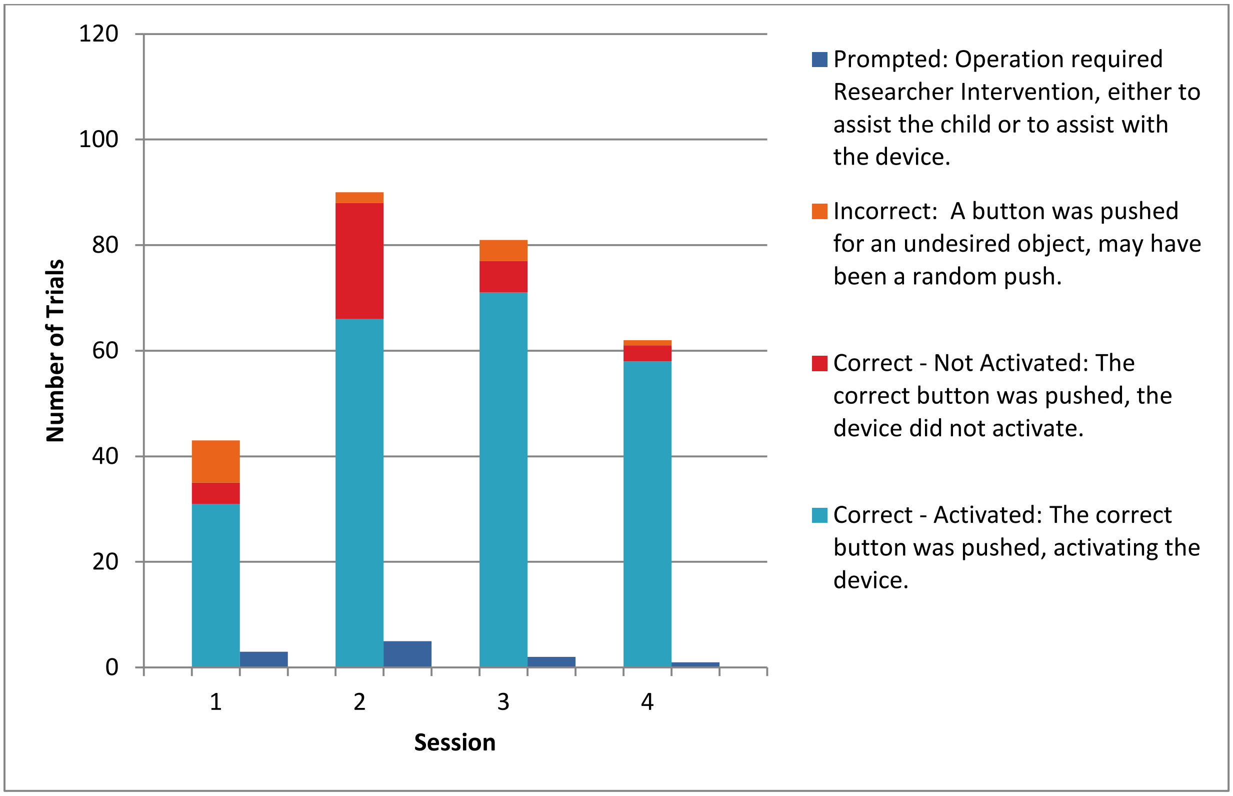


Figure 19 - Proportion of Trials by Session for Andre: The proportion of trials per session that required prompting, or resulted in the touching the incorrect button, correct button with activation of the device or correct button without activation of the device.

The number of correct trials as a proportion of the total trials stayed constant across sessions one and two and increased through sessions three and four (See Figure 19 and Table 8). In sessions one and two, three quarters of the trials resulted in the selection of the correct icon and device activation. This increased to four-fifths of the trials in session three and nine-tenths of the trials in session four. The total number of trials conducted peaked in session two and decreased across sessions three and four. This occurred due to the increase in difficulty of the task and increase in time with the preferred object, the same as for Caleb.

Within Andre's first 2 sessions the researcher noted that a similar pattern to one noted with Caleb was occurring. Andre would touch the correct icon and the device would not activate. This response of the device did not occur until after the 12th trial of the first session, and only happened 3 times out of 43 trials. However on all three occurrences during the first session, Andre would immediately retouch the screen to activate the device without prompting. This indicated to the researcher that the child may have experienced this issue before, as he was very familiar with the use of iPads. This pattern continued through sessions two, three and four, with a higher rate in session 2, Andre was always able to retouch the device independently and activate the voice output (See Table 9, Code D).

Table 9 - *Algorithm Analysis by Session for Andre*

Code	Sequence	Session 1	Session 2	Session 3	Session 4
A	Touch → Device not activated (independent)	0	0	0	0
B	Touch → Device Activated (Independent)	26	46	61	53
C	Touch → Incorrect (Independent)	3	2	3	1
D	Touch → Device not activated, Touch → Device Activated (Independent)	2	10	5	3
E	Touch → Device not activated, Touch → Device Activated (Researcher Intervention)	0	0	0	0
F	Touch →Device Activated (Prompted)	3	5	2	1
G	Touch → Device not activated (prompted)	0	0	0	0

The algorithm was also used to code data from Andre's sessions. Andre showed a high level of correct icon selection and device activation from the beginning of session one and continued to have a high level of success even when the array and button size were manipulated to the smallest level in phase 3, session 4 (See Table 9, code B). Andre also showed the pattern in responses, during which he would touch the device and it would not activate and then he would immediately touch the device again to activate it (See Table 9, code D). Andre did not require any researcher intervention at any point in the study to complete this sequence of behaviour.

Andre was able to use the device effectively to communicate his needs across all four sessions and three phases of the study. His accuracy and ability to use the device did not appear to be influenced by the increase in the array size and decrease in button size as the study progressed.

Summary

This chapter outlined the findings from this study examining the usability of the augmentative communication app Proloquo2Go, when the variables of button size and array size were manipulated. The data from the three subjects was examined separately in case study format due to the variation in skills and experience between the subjects. The rate of responding per session was examined, along with the amount of researcher intervention needed for successful completion of the task at each phase of the study. The number of correct trials and clustering of responses was also examined using the algorithm developed for analysis.

Caleb showed a high rate of responding across all phases of the study (See Figure 14, pg 59). The rate of researcher intervention needed was quite low across sessions one and two, a decreased to zero during sessions three and four. It was during Caleb's initial session that the pattern of selecting the correct icon, but the device not activating was noted by the researcher. After being prompted only three times to retouch the screen when this occurred, Caleb began completing the re-touch to activate the device independently and this continued for the remaining three sessions (See Table 5, pg 61). The overall rate of touching the device and the device not activating also decreased across sessions three and four, showing a possible training effect on how to activate the device effectively. Caleb was able to effectively use the device across all phases of the study to request desired items, indicating that array size and button size did not impact the usability of the device for his communication needs.

Tebey showed an inconsistent rate of responding and participation in tasks throughout the study. His rate of responding decreased across sessions, resulting from an unwillingness to participate in tasks and an increase in off task behaviour as sessions progressed (See Table 6, pg 63). Tebey required more researcher intervention to complete tasks as sessions continued, even requiring multiple prompts to complete a single response during session four (See Figure 16, pg 64 and Figure 17, pg 65). The methodology was adapted for Tebey, repeating phase 2 (3x3 array) during session 4, rather than moving on to phase 3 (4x4 array) due to concerns about performance and possible frustration with increasing task difficulty. However the rate of correct responding still decreased between sessions three and four, indicating that lack of participation and increased time off task may have influenced performance rather than increased array size and decreased button size. Tebey’s rate of correct independent responses decreased across all sessions, with session one showing the highest rate (See Table 7, pg 66). It is not possible to conclude that Tebey’s decrease in responding and accuracy were due to the manipulations of button size and array size as behaviour and time on task were confounding variables that may have influenced his performance.

Andre also showed a high rate of responding across all phases of the study (See Figure 19, pg 70). He needed low rates of researcher intervention (prompting) across all sessions, however the rates decreased across sessions three and four (See Table 8, pg 69). Andre also showed the pattern of selecting the correct icon, with no device activation. However he did not need researcher intervention to retouch the device, and independently re-touched the device from session one and on through the remaining sessions (See Code D, Table 9, pg 71). This indicated to the researcher that Andre may have experienced this pattern in previous interactions with using an iPad outside of the research study, as Andre had regular exposure to an iPad at home and school. Andre's accuracy of selecting the icon and ability to use the device did not appear to be influenced by the increase in array size and decrease in button size as the phases of the study progressed.

From these three subjects, two exhibited certain similarities of response rates as well as low influence of button size and array size whereas the third subject became less willing to participate as the study progressed which may have influenced his ability to use the device.

Conclusion

The purpose of this study was to examine the compatibility of the user interface characteristics of an augmentative communication app with the characteristics of individuals with autism spectrum disorder. This study specifically examined the effect that button size and array size within Proloquo2Go, an augmentative communication app, may have had on the usability of the app for children with autism spectrum disorder with varying characteristics. This was accomplished through a case study design with three subjects, involving three phases in which the variables of button size and array size were manipulated. It was found that two of the subjects exhibited similar response rates and patterns, showing low influence of button and array size changes on the usability of the app, however the third subject had a number of interfering behaviours and a lack of interest in participation as sessions progressed which may have contributed to the decrease in his rate of responding as the study progressed.

The research questions that we set out to explore with this study were:

1. How can current user interface characteristics on mobile technology be adapted to the characteristics of individuals with autism spectrum disorder?
2. How can the user interface within an augmentative communication app be adapted to the characteristics of individuals with autism spectrum disorder?
3. Does button size influence the usability of an app for individuals with autism spectrum disorder?

The current study shows that there are a number of ways that user interface characteristics on mobile technology can be adapted to the needs of individuals with autism spectrum disorder. The augmentative communication app Proloquo2Go contains many different features and settings that can be modified for each individual user including button size, array size, iconicity, colours, line thickness, button spacing and many more. Our data showed that for two of our subjects, button size and array size did not appear to influence the usability of the app.

Their rates of responding stayed consistent throughout all phases of the study and rates of correct selections increased while rates of researcher intervention decreased across all sessions. These subjects both showed a moderate to high level of receptive language on the intake interview, suggesting that this characteristic may lead to more success in the use of the device overall. Our data from the third subject is inconclusive, as there was an increase in off task behaviour and lack of participation as sessions continued. It is not possible to conclude that the changes in button size and array size influenced his performance in using the app due to a number of confounding variables. Subject 2’s parent reported a low level of receptive language during the intake interview, indicating that the ability to understand simple verbal instructions may be a characteristic to investigate more in relation to successful use of the device and specific device settings.

An additional theme that emerged from the parent interview, although not formally included in the interview, was each participant’s previous history with early intervention therapies. Subjects one and three had participated in structured therapy sessions both with a Speech and Language Pathologist and a behaviour therapist trained in Applied Behaviour Analysis therapy. They regularly participated in structured therapy sessions during which they were required to sit and attend to instructions from an adult, who controlled preferred items that were used for positive reinforcement. Subject two had no previous history of such interventions, with the exception of being on a waitlist for intervention at the outcome of the study. This difference may have contributed to subject three’s difficulty with sitting, attending, and allowing the researcher to handle preferred items while compounded with low receptive language skills.

There were no other patterns noted in comparing participant characteristics with the outcomes of the three phases of the study. As a result of the above observations, modifications to the theoretical framework are suggested for future research to include the variables of user experience (in both therapeutic interventions and with the device) and device characteristics (such as scroll sensitivity) which will be discussed further later (See Figure 20). This modification would allow for richer conclusions regarding the compatibility of user interface characteristics with the characteristics of individuals with autism spectrum disorder and incorporate information that is unique to each individual such as information about user experience with previous therapies and communication interventions.

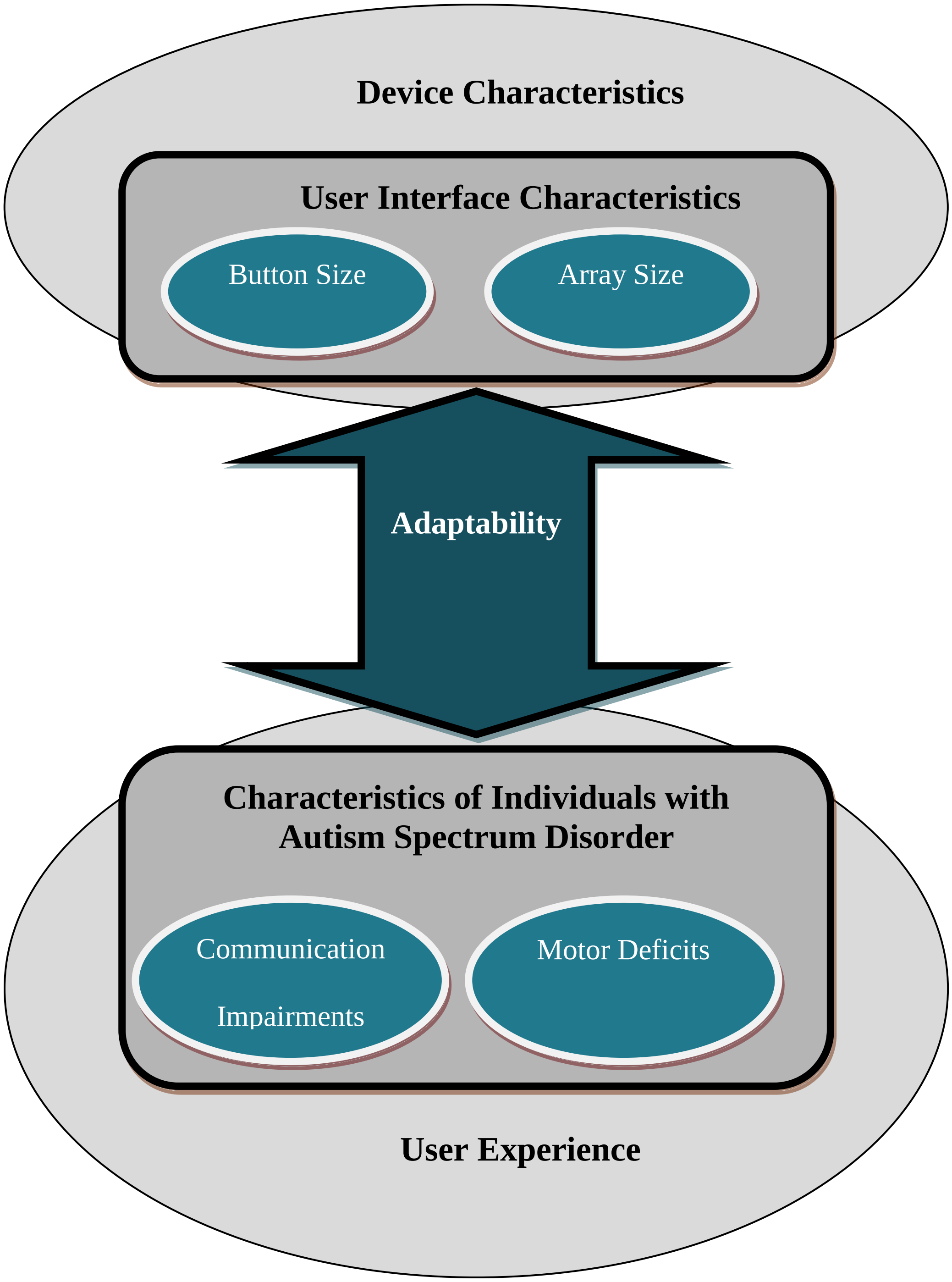


Figure 20 – Modified Theoretical Framework

Due to the nature of the population examined and the small sample size this study employed a case study design for data collection and analysis. Future research in this area may also include larger sample sizes with a more homogeneous group of subjects to develop a deeper understanding of the relationship between subject characteristics and the usability of the app. The number of conclusions that can be drawn from this study are somewhat limited by the small sample size and lack of between-subject comparisons.

The behaviour challenges that one participant exhibited restrict the conclusions that can be made from this study. For future research including a more thorough intake screening to control for past interventions that the child had received, may reduce the variability in subject performance. The researcher would also include a tested measure of attention span and compliance with following simple directions, rather than relying on parental self-report during intake interviews to determine eligibility to participate. Although there were challenges with subject 2's participation, his inclusion provides valuable diversity in the sample. Educators and professionals often must design interventions for children who have significant behavioural challenges and have received little to no previous intervention. Our results indicate that interventions involving tablet-based augmentative communication apps may be better suited to children after certain prerequisite skills in the area of attending have been learned, however further research in this area would be valuable.

One interesting trend that emerged from the data was the tendency of the device to not activate at times when the subject had chosen the correct icon and touched the screen. On some of these trials it was noted that the screen appeared to begin scrolling, suggesting that the child did not touch the screen with a finger that was stationary, but rather moving slightly up or down. Chien et al. (2015) experienced a similar issue with the initial testing of their iCan app, in which during a tap on the screen some participants would hook their finger a bit before leaving the surface of the device, causing the system to incorrectly recognize the action as scrolling. They observed an increase in frustration or other emotions when this occurred. An increase in frustration was also seen in the subjects of the current study when the device would not activate, although they were quickly redirected with researcher intervention. One subject had developed a self-adaptation for this issue, suggesting that this is perhaps an ongoing issue for him when using his personal iPad. This pattern in both this study and Chin et al. (2015) indicates that including a setting on touch-screen tablets which allows you to decrease the sensitivity to touch and turn off multi-touch gestures will be important for the inclusive use of the devices by a variety of populations. The issue warrants further research to determine how much a problem this could be, whether it is app specific, device specific and or seen across multiple platforms. As new touch-screen input tablets are developed they are becoming more sensitive to touch, which could increase the impact of this issue for inclusive design of newer devices.

Another research area to explore around the scrolling concern seen in this study would be the relationship of the scrolling to the motor deficits commonly exhibited by individuals with autism spectrum disorder. More sensitive equipment that could monitor touch characteristics such as forces, impulse, dwell time and horizontal movement, would allow for more precise measurements to be made during tablet based tasks. Comparing results for individuals with autism spectrum disorder to normative data in the same age group would allow for more concrete suggestions to be made in designing apps and tablet setting modifications for individuals with a variety of motor control issues.

There were a number of limitations in the research conducted in this study. A larger, more diverse group of subjects is recommended for further research to allow for more concrete conclusions around user interface characteristics and usability of the app for individuals with autism spectrum disorder. Further research into this area should include a direct fine motor skills assessment, rather than relying on a parent report measure. This would allow for more precise information about the motor skills of participants. The addition of an intelligence quotient measure would also be a valuable addition to future research, to control for variables around intelligence and functioning level.

The outcome from this study suggests that there is potential for creating a model that would guide the compatibility of the characteristics of individuals with autism spectrum to user interface design characteristics. The creation of such a model would be helpful for educators and professionals involved in the development of interventions for this population, as it would reduce the use of the current trial-and-error system of selecting user interface characteristics within apps saving time and resources. Gosnell et al.'s (2011) proposed feature matching model addresses the initial challenge of selecting the appropriate AAC app for each individual, however does not go deeper into specific user interface settings within AAC apps. In 2012, Dolic et al. proposed a model of standards for adaptable symbol based AAC that developers could use when creating apps which would take into account device and user dependable configuration. However this model still requires that users determine preferences around symbol type, size, interface layout and the use of colour and animation before utilizing the model. A further examination of both the characteristics of individuals with autism spectrum disorder and the user interface design characteristics of AAC apps would be needed to even begin the development of a system to match user characteristics with user interface characteristics. However the development of such a system would be arguably worth the time and research, as it would be invaluable to the professionals introducing these apps to individuals in hopes of facilitating communication and allowing them to function as communicating members of society.

References

Achmadi, D., Kagohara, D.M., van der Meer, L., O'Reilly, M.F., Lancioni, G.E., Sutherland, D., Lang, R., Marschik, P.B., Green, V.A. & Sigafoos, J. (2012). Teaching advanced operation of an iPod-based speech-generating device to two students with autism spectrum disorders. *Research in Autism Spectrum Disorders, 6* (4), 1258-1264. Doi: 10.1016/j.rasd/2012.05.005

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: Author.

American Speech-Language-Hearing Association. (1989). Competencies for speech-language pathologists providing services in augmentative communication. *American Speech-Language-Hearing Association, 31*, 107-110.

American Speech-Language-Hearing Association. (2005). Helping Children with Communication Disorders in the Schools. Retrieved from: http://www.readingrockets.org/article/helping-children-communication-disorders-schools

Angermeier, K., Schlosser, R.W., Luiselli, J.K., Harrington, C., & Carter, B. (2008). Effects of iconicity on requesting with the Picture Exchange Communication System in children with autism spectrum disorder. *Research in Autism Spectrum Disorder, 2*, 430-446. Doi: 10.1016/j.rasd.2007.09.004

Arthanat, S., Curtin, C., & Knotak, D. (2013). Comparative Observations of Learning Engagement by Students with Developmental Disabilities Using an iPad and Computer: A Pilot Study. *Assistive Technology, 25,* 204-213. Doi: 10.1080/10400435.2012.761293

Assistive Technology Lending Centre. (2015). Retrieved from: http://www.atlclibrary.org/

Autism Canada. (2011). Communication: Sign Language or Signed Speech. Retrieved from: http://www.autismcanada.org/treatments/comm/speechsign.html

Baron-Cohen, S. (1988). Social and pragmatic deficits in autism: Cognitive or affective? *Journal of Autism and Developmental Disorders, 18,* 379-402. Doi: 10.1007/BF02212194

Berkley, S.L., Zittel, L.L., Pitney, L.V., & Nichols, S.E. (2001). Locomotor and object control skills of children diagnosed with autism. *Adapted Physical Activity Quarterly, 18,* 405-416.

Beukelman, D.R., & Mirenda, P. (2005). *Augmentative and Alternative Communication: Supporting children and adults with complex communication needs* (3rd ed.). Baltimore: Paul H. Brookes.

Boesch, M.C., Wendt, O., Subramanian, A., & Hsu, N. (2013a). Comparative Efficacy of the Picture Exchange Communication System (PECS) versus a Speech-Generating-Device: Effects on Social-communicative Skills and Speech Development. *Augmentative and Alternative Communication, 29* (3), 197-209. Doi: 10.3109/07434618.2013.818059

Boesch, M. C., Wendt, O., Subramanian, A., & Hsu, N. (2013b). Comparative efficacy of the Picture Exchange Communication System (PECS) versus a speech-generating device: Effects on requesting skills. *Research in Autism Spectrum Disorders, 7,*480 – 493. Doi: 10.1015/j.rasd.2012.12.002

Bondy, A.S., & Frost, L.A. (1994). The Picture Exchange Communication System. *Focus on Autistic Behavior, 9* (3), 1-20. Doi: 10.1177/108835769400900301

Bondy, A.S., & Frost, L.A. (2001). The Picture Exchange Communication System. *Behavior Modification, 25* (5), 725-744. Doi: 10.1177/0145445501255004

Bristol, M.M. (1984). Family resources and successful adaptation to autistic children. In E. Schopler & G.B. Mesibov (Eds.), *The Effects of Autism on the Family* (289-310). New York: Plenum Press.

Brown, R. (1978). Why are signed languages easier to learn than spoken languages? (Part two). *Bulletin of the American Academy of Arts and Sciences, 32,* 25-44.

Carr, J.E., Nicholson, A.C., & Higbee, T.S. (2000). Evaluation of a brief multiple-stimulus preference assessment in a naturalistic context. *Journal of Applied Behavior Analysis, 33* (3), 353-357. Doi: 10.1901/jaba.2000.33-353

Cartmill, L., Rodger, S., & Ziviani, J. (2009). Handwriting of eight year old children with autism spectrum disorder: An exploration. *Journal of Occupational Therapy, Schools and Early Intervention*, *2*(2), 103-118. Doi: 10.1080/19411240903146426

Charlop-Christy, M. H., Carpenter, M., Le, L., LeBlanc, L. A., & Kellet, K. (2002). Using the picture exchange communication system (PECS) with children with autism: Assessment of PECS acquisition, speech, social-communicative behavior, and problem behavior. *Journal of Applied Behavior Analysis, 35*(3), 213-231. Doi: 10.1901/jaba.2002.35-213

Chen, K.B., Savage, A.B., Chourasia, A.O., Wiegmann, D.A., & Sesto, M.E. (2013). Touch screen performance by individuals with and without motor control disabilities. *Applied Ergonomics*, *44,* 297-302. doi: 10.1016.j/apergo.2012.08.004

Chien, M., Jheng, C., Lin, N., Tang, H., Taele, P., Tseng, W., & Chen, M.Y. (2015). iCAN: A tablet-based pedagogical system for improving communication skills of children with autism. *International Journal of Human-Computer Studies, 73,* 79-90. doi: 10.1016/j.ijhcs.2014.06.001

De Leo, G., Gonzales, C.H., Battagirl, P., & Leroy, G. (2011). A Smart-Phone Application and a Companion Website for the Improvement of the Communication Skills of Children with Autism: Clinical Rational, Technical Development and Preliminary Results. *Journal of Medical Systems, 35* (4), 703-711. Doi: 10.1007/s10916-009-9407-1

DeLeon, I.G., & Iwata, B.A. (1996). Evaluation of a multiple-stimulus presentation format for assessing reinforcer preferences. *Journal of Applied Behavior Analysis, 29*(4), 519-532. Doi: 10.1901/jaba.1996.29-519

Dolic, J., Pibernik, J. & Bota, J. (2012). Evaluation of Mainstream Tablet Devices for Symbol Based AAC Communication. Proceedings of the 6th KES international conference*:* *Agent and Multi-Agent Systems: technologies and applications.* Doi: 10.1007/978-3-642-30947-2_29

Durand, V.M. (1993). Functional Communication Training Using Assistive Devices: Effects on Challenging Behavior and Affect. *Augmentative and Alternative Communication, 9,* 168-176. Doi: 10.1080/07434619312331276571

Dyck, M., Piek, J., Hay, D., & Hallmayer, J. (2007). The relationship between symptoms and abilities in autism. *Journal of Developmental and Physical Disabilities, 19*, 251–261. Doi: 10.1007/s10882-007-9055-7

Flores, M., Musgrove, K., Renner, S., Hinton, V., Strozier, S., Franklin, S., & Hil, D. (2012). A comparison of communication using the Apple iPad and a picture-based system. *Augmentative and Alternative Communication, 28* (2), 74-84. Doi: 10.3109/07434618.2011.644579

Fuller, D. (1997). Effects of translucency and complexity on the associative learning of Blissymbols by cognitively normal children and adults. *Augmentative and Alternative Communication, 10,* 12-19. Doi: 10.1080/07434619712331277818

Ganz, J. B., & Simpson, R. L. (2004). Effects on communicative requesting and speech development of the picture exchange communication system in children with characteristics of autism. *Journal of Autism and Developmental Disorders, 34*(4), 395-409. Doi: 10.1023/B:JADD.0000037416.59095.d7

Ganz, J.B., Davis, J.L., Lund, E.M., Goodwyn, F.D., & Simpson, R.L. (2012). Meta-analysis of PECs with individuals with ASD: Investigation of targeted versus non-targeted outcomes, participant characteristics and implementation phase. *Research in Developmental Disabilities, 33,* 406-418. Doi: 10.1016/j.ridd.2011.09.023

Garfin, D., & Lord, C. (1986). Communication as a social problem in autism. In E. Schopler & G. Mesibov (Eds.), *Social Behaviour in Autism* (237-261). New York: Plenum Press.

Gernsbacher, M. A., Sauer, E., Geye, H., Schweigert, E., & Goldsmith H. H. (2008). Infant and toddler oral- and manual-motor skills predict later speech fluency in autism. *Journal of Child Psychology and Psychiatry, 49,* 43–50. Doi: 10.111/j.1469-7610-2007.01820.x

Gleason, J.B. (2001). *The development of language* (5th ed.). Boston: Allyn and Bacon.

Gosnell, J., Costello, J., & Shane, H. (2011). Using a clinical approach to answer “What communication apps should we use?” *Perspectives on Augmentative and Alternative Communication, 20*(3), 87-96. Doi: 10.1044/aac20.3.87

Green, D., Baird, G., Barnett, A.L., Henderson, L., Huber, J., & Henderson, S.E. (2002). The severity and nature of motor impairment in Asperger’s syndrome: a comparison with specific developmental disorder of motor function. *Journal of Child Psychology and Psychiatry, 43*(5), 655-668. Doi: 10.1111/1469-7610.00054

Hayes, G.R., Hirano, S., Marcu, G., Monibi, M., Nguyen, D.H., Yeganyan, M. (2010). Interactive visual supports for children with autism. *Personal and Ubiquitous Computing, 14* (7), 663-680. doi: 10.1007/s00779-010-0294-8

Hershberger, D. (2011). Mobile technology and AAC Apps from an AAC developer's perspective. *Perspectives on Augmentative and Alternative Communication, 20*(1), 28-33. Doi: 10.1044/aac20.1.28

Human Factors and Ergonomics Society. (2007). *American National Standard for Human Factors Engineering of Computer Workstations (ANSI/HRES Standard No. 100-2007).* Santa Monica, CA: Human Factors & Ergonomics Society.

Hurlbut, B., Iwata, B., & Green, J. (1982). Non-vocal language acquisition in adolescents with severe physical disabilities: Blissymbol versus iconic stimulus formats. *Journal of Applied Behavior Analysis, 15,* 241-258. Doi: 10.1901/jaba.1982.15-241

Johnson, B.P., Phillips, J.G., Papadopoulos, N., Fielding, J., Tonge, B., & Rinehart, N.J. (2013). Understanding macrographia in children with autism spectrum disorders. *Research in Developmental Disabilities, 34*, 2917-2926. Doi: 10.1016/j.ridd.2013.06.003

Kagohara, D.M., van der Meer, L., Achmadi, D., Green, V.A., O'Reilly, M.F., Mulloy, A., Lancioni, G.E., Lang, R., & Sigafoos, J. (2010). Behavioral Intervention Promotes Successful Use on an iPod-Based Communication Device by an Adolescent with Autism. *Clinical Case Studies, 9*(5), 328-338. doi: 10.1177/1534650110379633

Kagohara, D.M., van der Meer, L., Ramdoss, S., O'Reilly, M.F., Lancioni, G.E., Davis, T.N., Rispoli, M., Lang, R., Marschik, P.B., Sutherland, D., Green, V.A. & Sigafoos, J.

(2013). Using iPods and iPads in teaching programs for individuals with developmental disabilities: A systematic review. *Research in Developmental Disabilities*, *34*, 147-156. Doi: 10.1016/j.ridd.2012.07.027

Keskinen, T., Heimonen, T., Turunen, M., Rajaniemi, J., & Kauppinen, S. (2012). SymbolChat: A flexible picture-based communication platform for users with intellectual disabilities. *Interacting with Computers, 24,* 374-386. Doi: 10.1016/j.intcom.2012.06.003

King, M.L., Takeguchi, K., Barry, S.E., Rehfeldt, R.A., Boyer, V.E., & Matthews, T.L. (2014). Evaluation of the iPad in the acquisition of requesting skills for children with autism spectrum disorder. *Research in Autism Spectrum Disorders, 8,* 1107-1120. Doi: 10.1016/j.rasd.2014.05.011

Koul, R.K. & Lloyd, L.L. (1998). Comparison of graphic symbol learning in individuals with aphasia and right hemisphere brain damage. *Brain and Language, 62*, 398-421. Doi: 10.1006/brin.1997.1908

Koul, R.K., Schlosser, R.W., Sancibrian, S. (2001). Effects of Symbol, Referent, and Instructional Variables on the Acquisition of Aided and Unaided Symbols by Individuals with Autism Spectrum Disorder. *Focus on Autism and Other Developmental Disorders*, *16*(3), 162-169. doi: 10.1177/1088357608324715

Kozleski, E. (1991). Visual symbol acquisition by students with autism. *Exceptionality, 2*, 173-194. Doi: 10.1080/09362839109524782

Kratochwill, T.R., & Levin, J.R. (2014). Single-Case Intervention Research: Methodological and Statistical Advances. Washington DC: American Psychological Association.

Lord, C. & Paul, R. (1997). Language and communication in autism. In D. Cohen & F. Volkmar (Eds.), *Handbook of Autism and Pervasive Developmental Disorders* (195-225). New York: John Wiley and Sons.

Lorah, E.R., Tincani, M., Dodge, J., Gilroy, S., Hickey, A., & Hantula, D. (2013). Evaluating Picture Exchange and the iPad as a Speech Generating Device to Teach Communication to Young Children with Autism. *Journal of Developmental and Physical Disabilities, 25*(6), 637-649. Doi: 10.1007/s10882-013-9337-1

Lorah, E.R., Parnell, A., Whitby, P.S., & Hantula, D. (2014). A Systematic Review of Tablet Computers and Portable Media Players as Speech Generating Devices for Individuals with Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders, 45* (1). Doi: 10.1007/s10803-014-2314-4

Manjiviona, J., & Prior, M. (1995). Comparison of Asperberger syndrome and high-functioning autistic children on a test of motor impairment. *Journal of Autism and Developmental Disorders, 25,* 23-39. Doi: 10.1007/BF02178165

Mari, M., Castiellow, U., Marks, D., Marraffa, C., & Prior, M. (2003). The reach-to-grasp movement in children with autism spectrum disorder. *Philosophical Transactions of the Royal Society of London, Series B, Biological Sciences, 358,* 393-403. Doi: 10.1098/rstb.2002.1205

Mayes, S.D., & Calhoun, S.L. (2003). Ability profiles in children with autism: influence of age and IQ. *Autism*, *7*, 65-80.

McEachin, D., Smith, T., & Lovaas, O.I. (1993). Long-term outcome for children with autism who received early intensive behavioral treatment. *American Journal on Mental Retardation, 97,* 359-372.

Merriam, S.B. (1998). Qualitative Research and Case Study Applications in Education (2nd Ed.). San Francisco: Jossey-Bass.

Mirenda, P. (2008). A Back Door Approach to Autism and AAC. *Augmentative and Alternative Communication, 24*(3), 220-234. Doi: 10.1080/08990220802388263

Mirenda, P. & Locke, P.A. (1989). A Comparison of Symbol Transparency in Nonspeaking Persons with Intellectual Disabilities. *Journal of Speech and Hearing Disorders, 54*, 2, 131-302. Doi: 10.1044/jshd.5402.141

Mizuko, M. (1987). Transparency and ease of learning of symbols represented by Blissymbolics, PCS, and Picsyms. *Augmentative and Alternative Communication*, *3,* 129-136. Doi: 10.1080/07434618712331274409

Mizuko, M., & Reichle, J. (1989). Transparency and recall of symbols among intellectually handicapped adults. *Journal of Speech and Hearing Disorders, 54,* 627-633. doi: 10.1044/jshd.5404.627

Montee, B.B, Miltenberger, R.G., & Wittrock, D. (1995). An experimental analysis of facilitated communication. *Journal of Applied Behavior Analysis, 28* (2), 189-200. Doi: 10.1901/jaba.1995.28-189

Preston, D. & Carter, M. (2009). A Review of the Efficacy of the Picture Exchange Communication System Intervention. *Journal of Autism and Other Developmental Disorders, 39* (10), 1471-1486. Doi: 10.1007/s10803-09-0763-y

Provost, B., Lopez, B., & Heimerl, S. (2007). A comparison of motor delays in young children: Autism spectrum disorder, developmental delay, and developmental concerns. *Journal of Autism and Developmental Disorders, 37,* 321–328. Doi: 10.1007/s10803-006-0170-6

Rispoli, M.J., Franco, J.H., van der Meer, L., Lang, R. & Carmargo, S.P.H. (2010). The use of speech generating devices in communication interventions for individuals with developmental disabilities: A review of the literature. *Developmental Neurorehabilitation, 13* (4), 276-293. Doi: 10.3109/17518421003636794

Seal, B.C., & Bonvillian, J.D. (1997). Sign language and motor functioning in students with autistic disorder. *Journal of Autism and Developmental Disorders, 27,* 437-466. doi: 10.1023/A:1025809506097

Sesto, M.E., Irwin, C.B., Chen, K.B., Chourasia, A.O., & Wiegmann, D.A. (2012). Effect of Touch Screen Button Size and Spacing on Touch Characteristics of Users With and Without Disabilities. *Human Factors, 54* (3), p. 425-436. Doi: 10.1199/0018720811433831

Schepis, M.M., Reid, D.H., & Behrmann, M.M. (1996). Acquisition and functional use of voice output communication by persons with profound multiple disabilities. *Behavior Modification, 20,* 458-468. doi: 10.1177/01454455960204005

Schlosser, R.W. (2003). *The efficacy of augmentative and alternative communication: Toward evidence-based practice.* Boston: Academic Press.

Schlosser, R.W., & Sigafoos, J. (2002). Selecting graphic symbols for an initial request lexicon: Integrative review. *Augmentative and Alternative Communication, 18,* 102-123. doi: 10.1080/07434610212331281201

Schwartz, J.B. & Nye, C. (2006). Improving Communication for Children with Autism: Does Sign Language Work? *EBP Briefs, 1* (2), 1-17.

Shane, H., & Costello, J. (1994). *Augmentative communication assessment and the feature matching process.* Proceedings from the annual convention of the American Speech-Language-Hearing Association, New Orleans, LA.

Shane, H.C., Blackstone, S., Vanderheiden, G., Williams, M., & DeRuyter, F. (2012). Using AAC Technology to Access the World. *Assistive Technology, 24,* 3-13. Doi: 10.1080/10400435.2011.648716

Sigafoos, J. (2005). From Premack to PECS: 25 years of progress in communication intervention for individuals with developmental disabilities. *Educational Psychology, 25* (6), 601-607. Doi: 10.1080/01443410500344688

Sigafoos, J., Lancioni, G.E., O'Reilly, M.F., Achamadi, D., Stevens, M., Roche, L., et al. (2013). Teaching two boys with autism spectrum disorders to request the continuation of toy play using an iPad-based speech-generating-device. *Research in Autism Spectrum Disorders, 7,* 923-930. Doi: 10.1016/j.rasd.2013.04.003

Simons Foundation. (2015). *Simons Foundation Autism Research Initiative: Simons Simplex Collection.* Retrieved from http://sfari.org/resources/simons-simplex-collection

Sparrow, S., Cicchetti, D. & Balla, D., (2005). *Vineland Adaptive Behaviour Scales, Second Edition (Vineland-II).* Pearson Assessments: Bloomington, MN.

Spectronics. (2014). iPhone/iPad Apps for AAC. Retrieved from http://www.spectronics.com.au/article/iphoneipad-apps-for-aac

Still, K., Rehfeldt, R.A., Whelan, R., May, R. & Dymond, S. (2014). Facilitating requesting skills using high-tech augmentative and alternative communication devices with individuals with autism spectrum disorders: A systematic review. *Research in Autism Spectrum Disorders, 8,* 1184-1199. Doi: 10.1016/j.rasd.2014.06.003

Sulzer-Azaroff, B., Hoffman, A.O., Horton, C.B., Bondy, A. & Frost, L. (2009). The Picture Exchange Communication System (PECS): What Do the Data Say?. *Focus on Autism and Other Developmental Disabilities, 25* (2), 89-103. Doi: 10.1177/1088357609332743

Trottier, N., Kamp, L., & Mirenda, P. (2011). Effects of peer-mediated instructions to teach use of speech-generating devices to students with autism in social game situations. *Augmentative and Alternative Communication, 27,* 26-39. doi: 10.3109/07434618.2010.546810

van der Meer, L., Kagohara, D., Achmadi, D., O'Reilly, M.F., Lancioni, G.E., Sutherland, D., & Sigafoos, J. (2012a). Speech-generating devices versus manual signing for children with developmental disabilities. *Research in Developmental Disabilities, 33*(5), 1658-1669. Doi: 10.1016.j.ridd.2012.04.004

van der Meer, L., Didden, R., Sutherland, D., O'Reilly, M.F., Lancioni, G.E., & Sigafoos, J. (2012b). Comparing three augmentative and alternative communication modes for children with developmental disabilities. *Journal of Developmental and Physical Disabilities, 24* (5), 451-468. Doi: 10.1007/s10882-012-9283-3

van der Meer, L., & Rispoli, M. (2010). Communication interventions involving speech-generating devices for children with autism: A review of the literature. *Developmental Neurorehabilitation, 13,* 294-306. doi: 10.3109/17518421003671494

van der Meer, L., Sigafoos, J., O'Reilly, M.F., & Lancioni, G.E. (2011). Assessing preferences for AAC options in communication interventions for individuals with developmental disabilities: A review of the literature. *Research in Developmental Disabilities, 32,* 1422-1431. doi: 10.1016.j.ridd.2011.02.003

Venter, A. C., Lord, C., & Schopler, E. (1992). A follow-up study of high-functioning autistic children. *Journal of Child Psychology and Psychiatry, 33*, 489-507. Doi: 10.1111/j.1469-7610.1992.tb00887.x

Vygotsky, L.S. (1962). *Thought and language.* Cambridge, MA: MIT Press.

Wilkinson K.M., & Jagaroo, V. (2004). Contributions of visual cognitive neuroscience to AAC display design. *Augmentative and Alternative Communication, 20,* 123-136. doi: 10.3109/07434618.2012.704522

Wilkinson, K.M., Light, J., & Drager, K. (2012). Considerations for the Composition of Visual Scene Displays: Potential Contributors of Information from Visual and Cognitive Sciences. *Augmentative and Alternative Communication, 28*(3), 137-147. doi: 10.3109/07434618.2012.704522

Wodka, E.L., Mathy, P., & Kalb, L. (2013). Predictors of Phrase and Fluent Speech in Children with Autism and Severe Language Delay. *Pediatrics, 131* (4), 1128-1134. Doi: 10.1542/peds.2012-2221

Wong, C., Odom, S.L., Hume, K., Cox, A.W., Fettig, A., Kucharczyk, S., Brock, M.E., Plavnick, J.B., Fleury, V.P., & Schultz, T.R. (2014). *Evidence-Based Practices for Children, Youth and Young Adults with Autism Spectrum Disorder.* Chapel Hill: The University of North Carolina, Frank Porter Graham Child Development Institute, Autism Evidence-Based Practice Review Group.

Yoder, P., & Stone, W. L. (2006). Randomized comparison of two communication interventions for preschoolers with autism spectrum disorders. *Journal of Consulting and Clinical Psychology, 74* (3), 426-435. Doi: 10.1037/0022-006x.74.3.426

Appendix A – Recruitment Flyer

UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY

Research Study

Do you:

- Have a child between 3 and 6 years old, diagnosed with Autism Spectrum Disorder?
    - Do they use less than 10 words to communicate regularly?
    - Are they able to sit for 5-10 minutes?
- Want to help researchers test a new iPad based app that may help your child to communicate?

Participation is voluntary and will include a parent interview and up to 6 visits with your child to our lab in downtown Oshawa.

For more information please contact:

April Stauffer, Graduate Student Researcher
April.Stauffer@uoit.ca or 905-243-9834

or

Dr. Francois Desjardins, Associate Professor
Francois.Desjardins@uoit.ca

This study has been approved by the UOIT Research Ethics Board (certificate #14-001)

Dear Parent/Caregiver,

We are looking for parents and children to participate in a study entitled *User interface adaptability within augmentative communication apps for children with autism spectrum disorder.* This study is designed to explore the adaptability of Proloquo2Go, an iPad-based augmentative communication app which claims to assist individuals who are non-verbal with autism spectrum disorder to communicate. The children will help us to test the technology and assess what works best for them. Participants in the study should be between the ages of 3 and 6 with a diagnosis of autism spectrum disorder, be non-verbal (use less than 10 words regularly), and able to sit for 5-10 minutes at a time.

The study will take place at the Educational Informatics Lab (EI Lab) at the Faculty of Education, University of Ontario Institute of Technology in downtown Oshawa. Participation in the study will involve approximately 6 visits with your child to our lab at 11 Simcoe St N, Oshawa, ON. The first visit will be for an informal meeting to discuss the project, answer all questions and show you our lab. A play area with a variety of toys will be available. If you are interested in participating, you will be given detailed information and you will be asked to sign a consent form. Please note, even after you have signed the consent form participation is voluntary and you are free to decline or withdraw at any time with no impact on services available to your child.

All of the following visits will have your child participating in a number of iPad-based tasks in our laboratory while you observe. The child will use the iPad with Proloquo2Go to request desired items, with different settings used changing the button size for each visit. These visits will be videotaped. Each visit will last up to a maximum of 45 minutes. Beverages and snacks will be provided and breaks will be taken when needed. The researcher will be available for an interview after the sessions have been completed to share the information with you and to answer any questions you may have.

If you have any further questions regarding any aspect of this study or would like to participate, please contact April Stauffer (April.Stauffer@uoit.ca) or Dr. Francois Desjardins (Francois.Desjardins@uoit.ca). Please contact the UOIT Ethics and Compliance Officer (905-721-8668 Ext. 3693 or compliance@uoit.ca) if you have any questions or concerns about your rights as a participant.

Thank you for supporting this research!

April Stauffer, Research Assistant, EI Lab
Faculty of Education, University of Ontario Institute of Ontario
april.stauffer@uoit.ca
eilab.ca

Appendix B – Consent Form

Dear Parent/Caregiver,

We warmly invite you and your child to participate in a study entitled *User interface adaptability within augmentative communication apps for children with autism spectrum disorder*. This study is designed to explore the adaptability of Proloquo2Go, an iPad-based augmentative communication app which seeks to assist individuals who are non-verbal with autism spectrum disorder to communicate. Participants in the study should be between the ages of 3 and 6 with a diagnosis of autism spectrum disorder, be non-verbal (use less than 10 words regularly) and able to sit for short periods of time (5-10 minutes). Participation in this study is completely voluntary, the decision to participate or not will not affect the services available to your child.

The study will take place at the Educational Informatics Lab (EI Lab) at the Faculty of Education, University of Ontario Institute of Technology in downtown Oshawa. This study is being conducted by April Stauffer, a graduate student at the Faculty of Education, under the supervision of Dr. Francois Desjardins, an Associate Professor with the Faculty of Education, at the University of Ontario Institute of Technology (UOIT).

Purpose and Procedure:

The purpose of this research is to explore the adaptability of Proloquo2Go, an iPad-based augmentative communication app which claims to assist individuals who are non-verbal with autism spectrum disorder to communicate.

Specifically, we want to answer the following question:

How are current user interface characteristics on mobile technology adapted to the characteristics of individuals with autism?

Participation in the study will involve approximately 6 visits with your child to our lab at 11 Simcoe St N, Oshawa, ON. The first visit will be for an informal meeting to discuss the project, answer all questions and show you our lab. After that, if you choose to participate, we will schedule an interview in which we will discuss your child's interests and abilities, and review all necessary consent forms. A play area with a variety of toys will be available in the same room in which all visits will take place.

All of the following visits will have your child participating in a number of iPad-based tasks in our laboratory while you observe. The child will use the iPad with Proloquo2Go to request desired items, with different settings used changing the button size for each visit (See figure 1). These visits will be videotaped. Each visit will last up to a maximum of 45 minutes, with a few 5-10 minute blocks of requesting between rest breaks. Videos taken during the sessions in the lab will be analyzed for response time and time on task, showing us which settings on the app are most effective for your child. Beverages and snacks will be provided and breaks will be taken when needed. The researcher will be available after each session to share information with you and to answer any questions you may have. If your child is having difficulty participating during any of the visits, steps will be taken to maintain their comfort level such as reducing the difficulty of the task, taking longer breaks or rescheduling sessions if needed.

Potential Benefits:

There are three potential benefits to participating in this study. Your child will be exposed to an augmentative communication tool that may be an effective means of helping him/her to communicate his/her needs to you and interact socially.

There is also the social benefit of contributing to the growing body of research on autism spectrum disorder.

Upon completion of the study a letter can be provided, upon request, indicating that your child has used the Proloquo2Go app to assist in communication.

Storage of Data:

All interview and video data will be stored without your child's name. All video data will be stored on secure servers that are password protected. The video footage will not be used for anything outside of the laboratory and will be deleted after one year. No video or photo showing your child's face will ever be used in any publication.

Confidentiality:

The lead researcher, April Stauffer, will have the only record that includes your child's name and identifying information. This will be stored separately from all other data collected and destroyed after one year. All participants will be coded using an alias.

Your privacy shall be respected. No information about your identity will be shared or published without your permission, unless required by law. Confidentiality will be provided to the fullest extent possible by law, professional practice, and ethical codes of conduct.

Right to Withdraw:

Your son/daughter/minor under your guardianship's participation in this study is voluntary. You have the right to withdraw your son/daughter/minor under your guardianship at any time during the process. To withdraw at any time please contact April Stauffer, Francois Desjardins or the UOIT Ethics and Compliance Officer through phone, email or face to face. Any data you have provided up to that point will be deleted. Once results have been published it is difficult, if not impossible to withdraw results. You will be given, in a timely manner throughout the course of this research, information that is relevant to your decision to continue or withdraw from participation.

Participant Concerns and Reporting:

- By consenting to participate in this research, participants do not waive any legal rights.

- There is a small risk of your child becoming stressed while participating in this study due to a new environment, people and tasks. If your child is having difficulty participating during any of the visits, steps will be taken to maintain their comfort level such as reducing the difficulty of the task, taking longer breaks or rescheduling sessions if needed. You may withdraw from the study at any time with no negative consequences.

- This research has been reviewed and approved by the Research Ethics Board of the University of Ontario Institute of Technology on September 5, 2014. The REB number assigned by UOIT is #14-001. Please contact the UOIT Ethics and Compliance Officer (905-721-8668 Ext. 3693 or compliance@uoit.ca) if you have any questions or concerns about your rights as a participant or adverse events.

- By consenting to participate in this research, participants are not relinquishing the right to legal recourse in the case of research-related harm.

If you have further questions regarding any aspect of this study, please respond to April Stauffer through april.stauffer@uoit.ca or call [redacted].

Thank you so much for supporting this research!

Sincerely,

April Stauffer, Research Assistant, EI Lab
Faculty of Education, University of Ontario Institute of Ontario
april.stauffer@uoit.ca
eilab.ca

Consent to Participate

1. I have read the consent form and understand the study being described;

2. I have had the opportunity to ask questions and my questions have been answered. I am free to ask questions about the study in the future;

3. I freely consent for my son/daughter/minor under my guardianship to participate in this research study, understanding that I may discontinue participation at any time without penalty. A copy of this consent form can be made available to me at ______________________________.

Name of Participant (child) Date

Name of Parent/Guardian Signature of Researcher

Signature of Parent/Guardian

4. I consent for videotape to be taken of my son/daughter/minor under my guardianship.

Name of Participant (child) Date

Name of Parent/Guardian Signature of Researcher

Signature of Parent/Guardian

5. My right to withdraw has been reviewed with me, I renew my consent for my child to participate:

Session	Signature of Parent/Guardian	Date
2		
3		
4		
5		
6		

Appendix C – Stimulus Preference Assessment Procedure

Multiple Stimulus without Replacement (MSWO) Preference Assessment

Procedure:

1. Seven items will be included in each assessment. Parent/Caregiver input can be used to determine which objects to include.

2. List items on the data sheet.

3. The child should be seated in a chair positioned in front of a table. The items may be placed directly on the table, slightly out of reach, or on a large tray so they may be removed between presentations.

4. Allow the child to sample (edibles) or manipulate the toys before initiating the assessment.

5. Sequence items randomly in a straight line on the table or tray about 5 inches apart.

6. Instruct the child to 'pick one'.
7. Immediately after the selection, remove the remainder of items from reach to prevent multiple selections. Record the selected item on the data sheet next to the corresponding number. For example, the first item selected would be written down on the space marked '1'.

8. Allow the child to manipulate the item for 10 seconds, give a countdown of "3, 2, 1, my turn". Remove the item and place it out of sight.

9. Rotate the remaining items on the tray by moving the item on the left end to the right end and shifting the other items, before re-presenting to the child.

10. Present the remaining items and repeat the procedure (steps 6-8) as described above.

11. Continue with the procedure until all items are selected or until the child does not make a selection within 30 seconds of being told to 'pick one'. If the child does not choose, record all remaining items as 'not selected'.

12. Summarize the data by giving each item a ration based on the number of times it was selected (0 or 1) over the number of times it was available (1 to 7). The first four items selected would be given 1/1, 1/2, 1/3, 1/4, in the order that they were selected. If the child selected 4 items, but did not select any more items all unselected items would be given 0/5.

13. Conduct 3 sessions in the manner described above, and then sum the rations for each item across the sessions (see sample data sheet). Calculate the sum into a percentage (e.g. 4/16 = 0.25 = 25%). This shows us that an item was chosen 25% of the time it was available.

14. Once the final percentage score is calculated for each item, rank the items (from high to low) to indicate which items are predicted to be the most effective reinforcers.

References:

Carr, J.E., Nicholson, A.C., & Higbee, T.S. (2000). Evaluation of a brief multiple-stimulus preference assessment in a naturalistic context. *Journal of Applied Behavior Analysis, 33* (3).

DeLeon, I.G., & Iwata, B.A. (1996). Evaluation of a multiple-stimulus presentation format for assessing reinforcer preferences. *Journal of Applied Behavior Analysis, 29*, 519-532.

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Stimulus Preference Assessment Data Sheet

Date: ______________ Student: ________________ Assessor: _______________

Session Number

Choice Number	1	2	3
1			
2			
3			
4			
5			
6			
7			

Data Analysis

Object	1	2	3	Sum	Percentage

Preferred Items in order of preference:

1.	
2.	
3.	
4.	
5.	
6.	
7.	

2014 A.Stauffer

Appendix D – Parent Interview Form

Parent Interview Form

Child Pseudonym:	
Sex:	
Date of Birth:	
Diagnosis:	
How does your child indicate if they are frustrated or anxious?	

Introduction

For the following questions I will be covering language skills, motor skills, literacy, familiarity with technology and your child's preferences. Based on the information you give me, together we will rate the following statements as: usually, sometimes or never. Have visual present.

Root for all questions: "Does your child" "Does **______**", give clarification using examples if needed.

Listening and Understanding

	Usually	Sometimes	Never
Responds to his or her name spoken			
Demonstrates understanding of the meaning of the word no or yes			
Listens to a story for at least 5 minutes			
Points to at least 3 major body parts when asked (e.g. nose, mouth, feet)			
Points to common objects in a book or magazine when they are named (e.g. dog, car, cup)			
Listens to instructions (e.g. go sit down)			
Follows instructions with one action and one object (e.g. close the door, bring me the book)			

Talking

	Usually	Sometimes	Never
Makes sounds or gestures to get parent's or caregiver's attention (e.g. waves arms)			
Makes sounds or gestures if he/she wants an activity to stop or keep going (e.g. shakes head)			
Points to objects he/she wants that are out of reach			
Points or gestures to indicate preference when given a choice of 2 items (e.g. do you want this one or this one)			
Says one-word requests (e.g. up, more, milk)			
Names at least 3 objects, names at least 10 objects			
States own name when asked			
Answers or tries to answer with words when asked a question			
Says at least 50 recognizable words			

Motor Skills

	Usually	Sometimes	Never
Picks up small objects, less than 2 inches			
Moves objects from one hand to the other			
Picks up small objects using thumb and fingers			
Puts items into and out of a container (e.g. a block in a cup)			
Turns pages of a book			
Stacks small blocks or objects, without them falling			
Opens doorknobs			

Literacy

	Usually	Sometimes	Never
Identifies one or more alphabet numbers and distinguishes them from numbers			
Recognizes own name in printed form			
Identifies at least 10 letters			
Prints or writes letters			

Familiarity with Technology (Open Ended)

	Answer
What types of technology is your child familiar with?	
Are they exposed to tablets?	
Are they able to turn on and use a tablet for play activities?	
Do they use tablets routinely?	

Experience with Augmentative Communication

	Answer
Has your child ever used an augmentative communication system? (Eg. PECS, apps)	
If yes, continue with questions. If no, move on to Preferences.	
What level of training did your child receive? (Eg. Direct 1:1 teaching by a professional, modelling)	
Does your child continue to use the system?	
Do they require prompting to use it?	

Preferences

	Answer
What grabs your child's interest?	
Does he have favorite toys/activities?	
Is he/she motivated by food? What types?	
Would you object to using food during sessions?	

Closing

- Explanation of Research Process and Next Steps
- Any questions?

References

Adapted from: Sparrow, S.S., Cicchetti, D.V. & Balla, D.A. (2005). Vineland-II: Vineland Adaptive Behaviour Scales, Second Edition. Pearson PsychCorp.

Rating Scale (placed on table during interview)

Rating	The Individual
Usually	Usually performs the behaviour without help or reminders. Performed the behaviour at a younger age but has outgrown it.
Sometimes or Partially	Sometimes performs the behaviour without help or reminders Sometimes does it with help but sometimes needs help Performs part of the behaviour without help or reminders
Never	Never performs the behaviour without help or reminders Never performs the behaviour because he or she is • unable • too young • not allowed

Appendix E – Letter of Participation

AS April Stauffer
IBI Services

Date:

To whom it may concern:

I am writing this letter in regards to Child's name. Child's name participated in 4 training sessions using Proloquo2Go as an augmentative communication device during the fall of 2014. Proloquo2Go has been shown to be an effective communication tool for children with autism spectrum disorder. For the purposes of the training sessions, Proloquo2Go was loaded onto an iPad2 and used with a variety of settings. Child's name used Proloquo2Go to request: __________ and _________ when presented in an array of ____.

Please feel free to contact me for any further information.

Sincerely,

April Stauffer, B.Sc., OCT, M.A. Candidate
Senior IBI Therapist
[redacted]
april.stauffer@[redacted]

Appendix F – Schedule for Families

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Schedule for Families

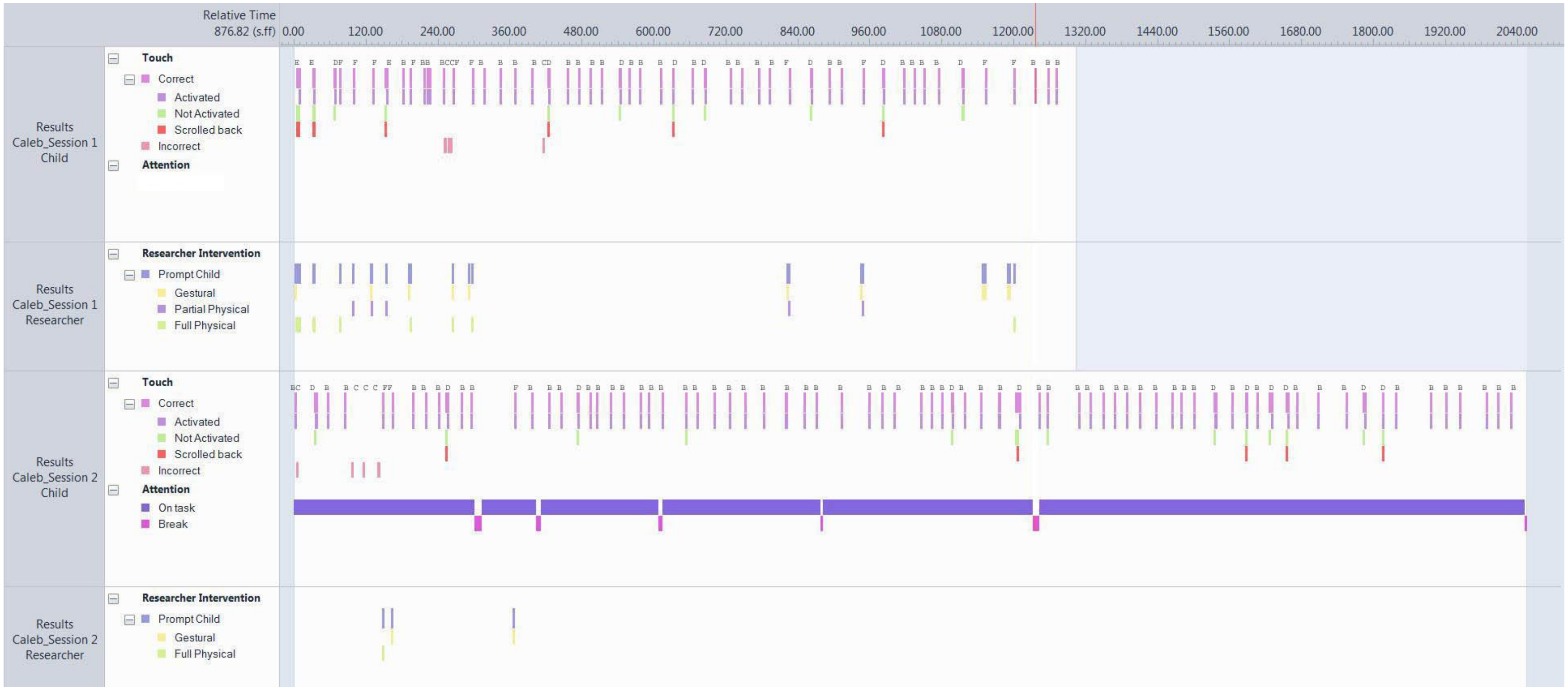
Visit	Description	Date
1	**Informal Meeting** We welcome you to come and visit our lab! April will discuss the project, answer any questions you have and show you the lab.	
2	**Intake Interview** A meeting to discuss your child's interests and abilities. Review the consent forms together.	
3	**Introduction to Proloquo2Go** April will sit with your child and through a series of trials, familiarize them with Proloquo2Go. The child will receive praise and desired objects or snacks to reinforce using the device.	
4	**Phase 1** The day will be very similar to visit 3, only the settings on the iPad will be slightly different.	
5	**Phase 2** The day will be very similar to visit 3, only the settings on the iPad will be slightly different.	
6	**Phase 3** The day will be very similar to visit 3, only the settings on the iPad will be slightly different.	

Notes:

- The researcher will be flexible for scheduling in the case that your child is having difficulty with participating.
- Sessions will be scheduled on Saturdays, when possible, to take advantage of free parking.
- A play area with a variety of toys will be provided in the same room where all visits are held. Your child will be encouraged to take breaks during sessions to decrease stress and get the ants out of their pants! :-)

Appendix G – Full Timelines

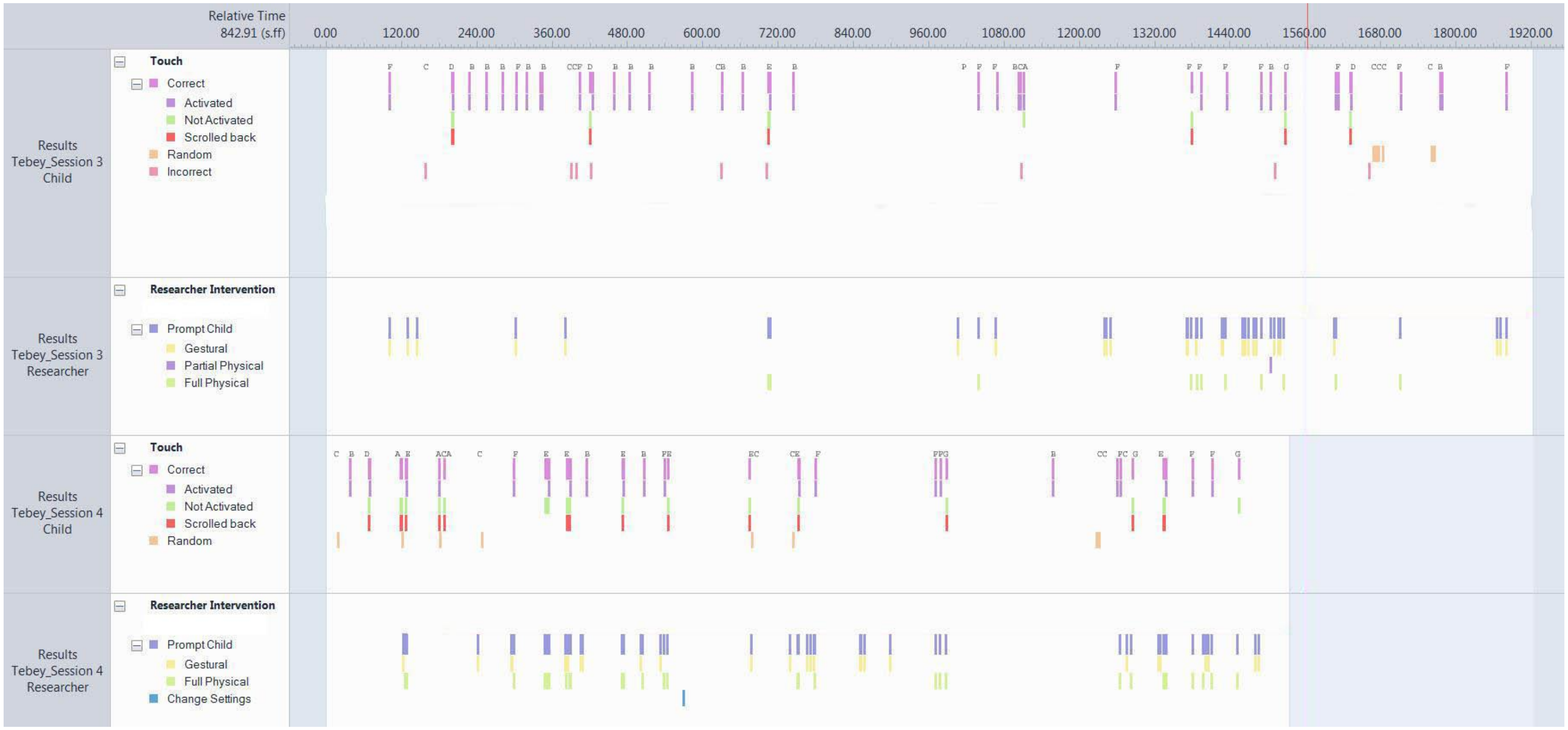
Caleb – Session One and Two



Caleb – Session Three and Four

Tebey – Session One and Two

Tebey – Session Three and Four



Andre – Session One and Two

Andre – Session Three and Four

Appendix H – Behaviour Analysis from ObserverXT

Observations	Subjects	Behaviors	Modifiers	Total duration	Rate per minute	Total number	Array Size	Session Duration
Caleb_Session 2	Child	Correct	Activated	-	2.33412	80	2x2	2056.45
Caleb_Session 2	Child	Correct	Not Activated	-	0.320942	11	2x2	2056.45
Caleb_Session 2	Child	Correct	Not Activated; Scrolled back	-	0.145883	5	2x2	2056.45
Caleb_Session 2	Child	Correct	Scrolled back	-	-	-	2x2	2056.45
Caleb_Session 2	Child	Incorrect	<No Modifier>	-	0.175059	6	2x2	2056.45
Caleb_Session 2	Child	On task	<No Modifier>	2009.6	0.175059	6	2x2	2056.45
Caleb_Session 2	Child	Break	<No Modifier>	46.8472	0.175059	6	2x2	2056.45
Caleb_Session 2	Researcher	Prompt Child	Full Physical	-	0.0291765	1	2x2	2056.45
Caleb_Session 2	Researcher	Prompt Child	Gestural	-	0.0583531	2	2x2	2056.45
Caleb_Session 3	Child	Correct	Activated	-	2.48005	63	3x3	1524.16
Caleb_Session 3	Child	Correct	Not Activated	-	0.118098	3	3x3	1524.16
Caleb_Session 3	Child	Correct	Not Activated; Scrolled back	-	0.118098	3	3x3	1524.16
Caleb_Session 3	Child	Correct	Scrolled back	-	-	-	3x3	1524.16
Caleb_Session 3	Child	Incorrect	<No Modifier>	-	0.118098	3	3x3	1524.16
Caleb_Session 4	Child	Correct	Activated	-	1.37825	31	4x4	1349.54
Caleb_Session 4	Child	Correct	Not Activated	-	0.0889193	2	4x4	1349.54
Caleb_Session 4	Child	Correct	Not Activated; Scrolled back	-	0.0889193	2	4x4	1349.54
Caleb_Session 4	Child	Correct	Scrolled back	-	-	-	4x4	1349.54
Andre_Session 1	Child	Correct	Activated	-	2.40083	31	1x2	774.733
Andre_Session 1	Child	Correct	Not Activated	-	0.154892	2	1x2	774.733
Andre_Session 1	Child	Correct	Not Activated; Scrolled back	-	0.154892	2	1x2	774.733
Andre_Session 1	Child	Correct	Scrolled back	-	-	-	1x2	774.733
Andre_Session 1	Child	Incorrect	<No Modifier>	-	0.619568	8	1x2	774.733

Observations	Subjects	Behaviors	Modifiers	Total duration	Rate per minute	Total number	Array Size	Session Duration
Andre_Session 1	Child	On task	<No Modifier>	774.733	0.077446	1	1x2	774.733
Andre_Session 1	Researcher	Prompt Child	Gestural	-	0.232338	3	1x2	774.733
Andre_Session 2	Child	Correct	Activated	-	1.89957	66	4x4	2084.69
Andre_Session 2	Child	Correct	Not Activated	-	0.23025	8	4x4	2084.69
Andre_Session 2	Child	Correct	Not Activated; Scrolled back	-	0.402938	14	4x4	2084.69
Andre_Session 2	Child	Correct	Scrolled back	-	-	-	4x4	2084.69
Andre_Session 2	Child	Incorrect	<No Modifier>	-	0.0575626	2	4x4	2084.69
Andre_Session 2	Child	On task	<No Modifier>	1682.18	0.402938	14	4x4	2084.69
Andre_Session 2	Child	Off task	<No Modifier>	73.3282	0.143906	5	4x4	2084.69
Andre_Session 2	Child	Break	<No Modifier>	329.177	0.201469	7	4x4	2084.69
Andre_Session 2	Researcher	Prompt Child	Full Physical	-	0.0287813	1	4x4	2084.69
Andre_Session 2	Researcher	Prompt Child	Gestural	-	0.115125	4	4x4	2084.69
Andre_Session 3	Child	Correct	Activated	-	2.55415	71	3x3	1667.87
Andre_Session 3	Child	Correct	Not Activated	-	0.215844	6	3x3	1667.87
Andre_Session 3	Child	Incorrect	<No Modifier>	-	0.143896	4	3x3	1667.87
Andre_Session 3	Researcher	Prompt Child	Gestural	-	0.071948	2	3x3	1667.87
Andre_Session 4	Child	Correct	Activated	-	3.18672	58	4x4	1092.03
Andre_Session 4	Child	Correct	Not Activated	-	0.16483	3	4x4	1092.03
Andre_Session 4	Child	Incorrect	<No Modifier>	-	0.0549434	1	4x4	1092.03
Andre_Session 4	Researcher	Assist with Device	<No Modifier>	769.723	0.0549434	1	4x4	1092.03
Tebey_Session 1	Child	Correct	Activated	-	3.38456	50	1x2	886.379
Tebey_Session 1	Child	Correct	Activated; Scrolled back	-	0.0676912	1	1x2	886.379
Tebey_Session 1	Child	Correct	Not Activated	-	0.406147	6	1x2	886.379
Tebey_Session 1	Child	Correct	Not Activated; Scrolled back	-	1.42152	21	1x2	886.379

Observations	Subjects	Behaviors	Modifiers	Total duration	Rate per minute	Total number	Array Size	Session Duration
Tebey_Session 1	Child	Correct	Scrolled back	-	-	-	1x2	886.379
Tebey_Session 1	Child	Incorrect	<No Modifier>	-	1.08306	16	1x2	886.379
Tebey_Session 1	Researcher	Assist with Device	<No Modifier>	793.621	0.338456	5	1x2	886.379
Tebey_Session 1	Researcher	Prompt Child	Full Physical	-	0.676912	10	1x2	886.379
Tebey_Session 1	Researcher	Prompt Child	Gestural	-	0.338456	5	1x2	886.379
Tebey_Session 2	Child	Correct	Activated	-	2.11121	69	2x2	1960.96
Tebey_Session 2	Child	Correct	Activated; Not Activated; Scrolled back	-	0.0305973	1	2x2	1960.96
Tebey_Session 2	Child	Correct	Activated; Scrolled back	-	-	-	2x2	1960.96
Tebey_Session 2	Child	Correct	Not Activated	-	0.611946	20	2x2	1960.96
Tebey_Session 2	Child	Correct	Not Activated; Scrolled back	-	0.611946	20	2x2	1960.96
Tebey_Session 2	Child	Correct	Scrolled back	-	-	-	2x2	1960.96
Tebey_Session 2	Child	Random	<No Modifier>	-	0.0305973	1	2x2	1960.96
Tebey_Session 2	Child	Incorrect	<No Modifier>	-	0.0917919	3	2x2	1960.96
Tebey_Session 2	Child	On task	<No Modifier>	945.358	1.1321	37	2x2	1960.96
Tebey_Session 2	Child	Off task	<No Modifier>	734.319	1.1321	37	2x2	1960.96
Tebey_Session 2	Child	Break	<No Modifier>	281.28	0.183584	6	2x2	1960.96
Tebey_Session 2	Researcher	Assist with Device	<No Modifier>	1719.05	0.183584	6	2x2	1960.96
Tebey_Session 2	Researcher	Prompt Child	Full Physical	-	1.40748	46	2x2	1960.96
Tebey_Session 2	Researcher	Prompt Child	Gestural	-	0.703738	23	2x2	1960.96
Tebey_Session 2	Researcher	Prompt Child	Partial Physical	-	0.0611946	2	2x2	1960.96
Tebey_Session 3	Child	Correct	Activated	-	1.30987	42	2x2	1923.85
Tebey_Session 3	Child	Correct	Not Activated	-	0.0935624	3	2x2	1923.85

Observations	Subjects	Behaviors	Modifiers	Total duration	Rate per minute	Total number	Array Size	Session Duration
Tebey_Session 3	Child	Correct	Not Activated; Scrolled back	-	0.280687	9	2x2	1923.85
Tebey_Session 3	Child	Correct	Scrolled back	-	-	-	2x2	1923.85
Tebey_Session 3	Child	Random	<No Modifier>	-	0.187125	6	2x2	1923.85
Tebey_Session 3	Child	Incorrect	<No Modifier>	-	0.311875	10	2x2	1923.85
Tebey_Session 3	Child	On task	<No Modifier>	1923.85	0.0311875	1	2x2	1923.85
Tebey_Session 3	Researcher	Assist with Device	<No Modifier>	542.731	0.0311875	1	2x2	1923.85
Tebey_Session 3	Researcher	Prompt Child	Full Physical	-	0.37425	12	2x2	1923.85
Tebey_Session 3	Researcher	Prompt Child	Gestural	-	0.873249	28	2x2	1923.85
Tebey_Session 3	Researcher	Prompt Child	Partial Physical	-	0.0311875	1	2x2	1923.85
Tebey_Session 4	Child	Correct	Activated	-	0.859301	22	3x3	1536.13
Tebey_Session 4	Child	Correct	Not Activated	-	0.195296	5	3x3	1536.13
Tebey_Session 4	Child	Correct	Not Activated; Scrolled back	-	0.703064	18	3x3	1536.13
Tebey_Session 4	Child	Correct	Scrolled back	-	-	-	3x3	1536.13
Tebey_Session 4	Child	Random	<No Modifier>	-	0.351532	9	3x3	1536.13
Tebey_Session 4	Researcher	Assist with Device	<No Modifier>	1347.85	0.0781182	2	3x3	1536.13
Tebey_Session 4	Researcher	Prompt Child	Full Physical	-	1.24989	32	3x3	1536.13
Tebey_Session 4	Researcher	Prompt Child	Gestural	-	1.01554	26	3x3	1536.13
Tebey_Session 4	Researcher	Change Settings	<No Modifier>	-	0.0390591	1	3x3	1536.13
Caleb_Session 1	Child	Correct	Activated	-	2.43507	53	1x2	1305.92
Caleb_Session 1	Child	Correct	Not Activated	-	0.275668	6	1x2	1305.92
Caleb_Session 1	Child	Correct	Not Activated; Scrolled back	-	0.367557	8	1x2	1305.92
Caleb_Session 1	Child	Correct	Scrolled back	-	-	-	1x2	1305.92

Observations	Subjects	Behaviors	Modifiers	Total duration	Rate per minute	Total number	Array Size	Session Duration
Caleb_Session 1	Child	Incorrect	<No Modifier>	-	0.229723	5	1x2	1305.92
Caleb_Session 1	Child	On task	<No Modifier>	1305.92	0.0459447	1	1x2	1305.92
Caleb_Session 1	Researcher	Prompt Child	Full Physical	-	0.459447	10	1x2	1305.92
Caleb_Session 1	Researcher	Prompt Child	Gestural	-	0.505391	11	1x2	1305.92
Caleb_Session 1	Researcher	Prompt Child	Partial Physical	-	0.229723	5	1x2	1305.92
Caleb_Session 4_Jess	Child	Correct	Activated	-	1.27566	29	4x4	1364
Caleb_Session 4_Jess	Child	Correct	Not Activated	-	0.0439881	1	4x4	1364
Caleb_Session 4_Jess	Child	Correct	Not Activated; Scrolled back	-	0.0439881	1	4x4	1364
Caleb_Session 4_Jess	Child	Correct	Scrolled back	-	0.0439881	1	4x4	1364
Caleb_Session 4_Jess	Child	Random	<No Modifier>	-	0.219941	5	4x4	1364
Caleb_Session 4_Jess	Child	Incorrect	<No Modifier>	-	0.0439881	1	4x4	1364
Caleb_Session 4_Jess	Child	On task	<No Modifier>	1364	0.0439881	1	4x4	1364
Caleb_Session 4_Jess	Researcher	Prompt Child	Gestural	-	0.307917	7	4x4	1364
Caleb_Session 4_Jess	Researcher	Prompt Child	Partial Physical	-	0.0439881	1	4x4	1364
Andre_Session 3_Jess	Child	Correct	Activated	-	2.49389	70	3x3	1684.12
Andre_Session 3_Jess	Child	Correct	Not Activated	-	0.106881	3	3x3	1684.12

Observations	Subjects	Behaviors	Modifiers	Total duration	Rate per minute	Total number	Array Size	Session Duration
Andre_Session 3_Jess	Child	Random	<No Modifier>	-	0.106881	3	3x3	1684.12
Andre_Session 3_Jess	Child	Incorrect	<No Modifier>	-	0.142508	4	3x3	1684.12
Andre_Session 3_Jess	Child	On task	<No Modifier>	1684.12	0.035627	1	3x3	1684.12
Andre_Session 3_Jess	Researcher	Prompt Child	Gestural	-	0.106881	3	3x3	1684.12