# Exploration of Computer Game Interventions in Improving Gaze Following Behavior in Children with Autism Spectrum Disorders

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Thesis submitted to the faculty of the Virginia Polytechnic Institute and State University in

partial fulfillment of the requirements for the degree of

Master of Science
In
Industrial and Systems Engineering

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March 21st, 2011
Blacksburg, Virginia

Keywords: gaze following, autism spectrum disorders, interaction design, inclusive design

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## ABSTRACT

Statistics show the prevalence of autism spectrum disorder (ASD), a developmental delay disorder, is now 1 in 110 children in the United States (Rice, 2009), nearing 1% of the population. Therefore, this study looked at ways modern technology could assist these children and their families. One deficit in ASD is the inability to respond to gaze referencing (i.e. follow the eye gaze of another adult/child/etc), a correlate of the responding to joint attention (RJA) process. This not only affects the way they appear to society, but it also affects social development, communication skills, and play skills later in life (Whalen & Schreibman, 2003), making early intervention of RJA is an integral part of a successful social skills program.

This study developed design guidelines, as well as offered and evaluated a design framework, adding to the limited literature regarding technology and ASD intervention. The game was developed within behavior analytic framework, undergoing several iterations, developing a functional prototype that was analyzed in three parts. The first part identified which elements needed redesign in light of the study population. Second, a collaborative prototyping participatory design group was formed in which the elements from the previous part of the study were assigned guidelines. The final part of the study included an evaluation by those with ABA experience, evaluating if the game correctly encompassed and mirrored traditional face-to-face ABA interventions. The study's contributions were the finalized design guidelines and design framework, as well as additional research on harnessing technology in ASD interventions.

When you take a drug to treat high blood pressure or diabetes, you have an objective test to measure blood pressure and the amount of sugar in the blood. It is straightforward. With autism, you are looking for changes in behavior…

***-- Temple Grandin, Autistic Author, Speaker, and Expert; Professor, Colorado State U***

# ACKNOWLEDGEMENTS

I sincerely thank my advisory committee for their continued and unending support. Acting as the chair of my committee, Dr. Winchester has left me feeling renewed and spirited even in the face of continued challenges. As members, Dr. Scarpa and Dr. Smith-Jackson have provided excellent guidance, answering my countless questions and emails. My committee supported all my decisions, however complex, allowing me to learn how to garner my own fervor, leaving me with great gain in my planning skills. Additionally, the varying perspectives and backgrounds of the committee allowed this interdisciplinary project to come together as one solid piece of research.

I extend gratitude to Michael Hawthorne for volunteering his time to development of the game prototype. Mike spent 40+ hours coding each element and his patience with iterations and last-minute changes is greatly appreciated. From the start, Katrina Ostmeyer lent advice from a behavior analytic point of view and this project certainly would not be what it is without her assistance.

Dr. Gregory Abowd, Dr Agata Rozga, and the Technology and Autism class of Georgia Tech are sincerely thanked for their evaluation of the game design. Their vast experience in the field has given irreplaceable input that has strengthened the game in such a way that more valid conclusions may be drawn from the study. Additionally, the Center for Human Computer Interaction at Virginia Tech, as well as the Human Factors and Ergonomics Society student group at George Mason University, evaluated and lent advice during the development of the game prototype. Having this multitude of viewpoints help to correct errors that were previously unrecognized.

Cheri Conte-Jordine, president of the Parent Advisory Counsil (PAC) for Mercer Country Special Services School District, was an excellent help in connecting with the district for the ABA evaluation portion of the study. Cheri was very enthusiastic about the research and I am grateful for her willingness and participation.

To my friends and family who have enjoyed the highs and suffered the lows of this research, I love each and every one of you, and I certainly couldn't have done any of this without you. Especially Nicholas, my strong older cousin living with ASD: hindsight tells me that you are the reason why I've ended up where I am, thank you.

This project remains incredibly important to me and I appreciate all those who take the time to read and consider this innovative approach to ASD intervention. This population is growing and finding ways to keep up with assistance is vital.

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# CHAPTER 1. INTRODUCTION

Although information about autism spectrum disorders (ASDs) is becoming more readily available to the general public, the severity range and intricacies of these disorders remains to be seen. ASD is the umbrella term for a spectrum of disorders characterized by developmental delays, including social and communication deficits, as well as repetitive patterns of behavior (American Psychiatric Association [*DSM-IV-TR*], 2000). The most severe part of this umbrella, according to the National Institute of Neurological Disorders and Stroke (2009), is autistic disorder, most commonly known as autism. A milder form of autistic disorder is referred to as Asperger's syndrome, which lacks the language delay seen in more severe autistics (Moldin & Rubenstein, 2006). Two less common disorders on the autism spectrum are Rett's syndrome and childhood disintegrative disorder. Rett's syndrome occurs primarily in girls and is characterized by a regression in language and abnormal physical features (Moldin & Rubenstein, 2006). Childhood disintegrative disorder displays some features similar to low-functioning autism, but includes a period of normal development followed by a regression in social skills (National Institute of Neurological Disorder and Stroke, 2009). Finally, for those children who display some, but not all, of the classical symptoms of an autistic disorder, the term Pervasive Developmental Disorder, Not Otherwise Specified (PDD-NOS) is utilized, with some specialists referring to it as "atypical autism" because of its presentation (Autism Program at Yale, 2010).

Because of the vast range of detrimental effects ASD has on the population both socially and economically, the current study aimed to investigate how interactive technologies could be deployed through the conceptualization and prototypication of an

interactive game to train gaze following, as well as contribute to the limited body of literature that exists regarding computer science, technology, and ASD. The present study examined two main research questions: 1) In regards to the basic elements of a computer-based game for children with ASD, what are the design guidelines that help facilitate successful development of the intervention? and 2) To what extent does this game format appropriately mirror the ABA guidelines and practices used in the intervention of children with ASD, specifically in terms of gaze-following behavior augmentation, a subset of RJA training? In answering the research questions, the following deliverables are offered: 1) a set of general design guidelines for use in the development of computer and video games as interventions in the treatment of ASD, and 2) a design framework implemented as a computer-based paper prototype developed with Microsoft PowerPoint (v. 2008). In the current study, the design framework is defined as a functional prototype, which represents an exemplar game design inclusive of the validated ABA principles used in traditional face-to-face therapies for the augmentation of gaze following behavior.

Having a reproducible (i.e. one that can be copied and distributed) intervention, such as a computer or video game, would give more options to not just parents and guardians, but also clinicians and therapists. As shown in the following sections, current treatment of ASD includes intensive intervention. Intensive is defined as 25 hours per week, 52 weeks per year. A tremendous amount of both time and money is invested into the treatment of children with ASD. It is possible that a computer-based intervention could help to alleviate some of the time commitments needed for that many hours of face-to-face therapy, as well as possibility mitigate some of the resource costs for school

and therapy systems. To understand the population and the main stakeholders of this study, as well as the need for research like this, the following sections walk the reader through the basic presentation of someone with ASD, the current prevalence of ASD within the United States, the treatments available to someone with ASD, both substantiated and unsubstantiated, and finally, the costs of living with ASD, directly and indirectly.

### *1.1 Presentation of ASDs*

At this point in time, ASDs lack clear biological causes or markers; therefore, behavior is used as the basis for diagnosis. People with ASD may present differently in terms of overt and covert symptoms, as well as in their personality. This inherent variability and lack of a clear cause introduces additional difficulties in treatment for ASD. Although the presentation may differ, there are some universal characteristics. Social deficits are the principle and most notable characterizations of ASDs. The ability of a person with ASD to interact appropriately with another person is impaired. As an infant, someone with ASD may exhibit a lack of responsiveness towards their caregivers through a lack of eye contact and social smiling. In childhood, someone with ASD may first appear to be undergoing normal development intellectually and educationally; however, they may show signs of indifference toward peer interaction (National Institute of Neurological Disorders and Stroke, 2009). Without behavioral intervention, social skill deficits and behavioral excesses will follow the child into adulthood, making it difficult to form functional relationships with peers and lead a normal life. Below is a good generalized description of a child presenting signs of having ASD (Maurice, Green, & Luce, 1996):

*"Jeffrey was 2.5 years old when his parents first heard the word autism used to explain his peculiar behavior. His life appeared to start out normally. They remembered him to be an affectionate baby who reached each developmental milestone like any other young child. And, like any other family, they had significant hopes and aspirations for their firstborn. Their troubles began when Jeffery's day care director commented that he seemed passive and isolated in his play. Instead of joining in with the art and play activities, he spent his time lining objects, opening and closing cabinet doors, repeatedly flushing the toilet, or simply sitting passively in a corner. By the time he was 3 years old, he spoke fewer than 50 words and rarely placed words together to form a sentence. On the other hand, his parents expressed that he seemed exceptionally smart in some areas. He could identify most colors when asked, complete complex puzzles, and count to 20. Although they did not fully understand the inconsistencies in his development, they were convinced that they needed to do something extraordinary to help him."*

### *1.1.1 Behavioral Deficits*

Language delay is one of the most prominent presentations of behavioral deficit in young children with ASD. This is a deficit experienced by many children other than those with ASD, for example, a child who is deaf. The difference lies within the social compensation used for the delay. For instance, autistic children do not tend to compensate for this delay with other means of social communication (i.e. using gestures or giving eye contact), whereas children without ASD would tend to do so (Wetherby & Prutting, 1984).

Aside from a delay in language, children with ASD also display deficits in original language production, leading to recitation and stereotyped phrasing. A child with ASD might recite passages from a favorite book, television commercial or movie.

In some cases, the child might have the ability to memorize the exact wordage; however, it is not always clear if the meaning of what they are reciting is understood. Finally, stereotyped phrasing is the use of a commonly heard phrase to answer a question the child might be uncomfortable with. For example:

*Teacher: "John, How do you feel when students do not let you play with them?"*

*Child: "I'm sorry, I really need to get going, I'll call you later."*

Here, the phrase that the child used does not fit the question that was asked of him and was used a means to escape or avoid the question that was posed. (Moldin & Rubenstein, 2006).

Aside from language deficits, children with ASDs also have trouble with imitation, imaginative play, and nonverbal communication (Moldin & Rubenstein, 2006). Part of the nonverbal communication deficit seen with ASD is joint attention (Presented in Section 2.1), which is considered a clear difference between autism and other developmental disorders, such as mental retardation, as well as a significant predictor of language development in autistic children (Mundy, Sigman, & Kasari, 1990).

### *1.1.2 Behavioral Excesses*

Echolalia is considered to be a behavioral excess and is the term used for the repetition of what another person has just said. For example:

*Parent: "Hi John, How are you doing today?"*

*Child repeats: "Hi John, How are you doing today?"*

Behavioral excess may also be in the form of self-stimulation, which includes hand flapping, spinning of the body or of objects, and rubbing. It may also include perseverations with objects that interfere in normal daily functioning. For example, a

child who is so intensely concentrated and focused on his/her interest in fire trucks may feel the need to bring a toy fire truck to every place they go. Repetitive behaviors and restricted interests are also characterizations of ASD and give rise to a need for stringent daily routine. A child may experience extreme emotional distress when facing a change in their everyday routine or rituals. The rituals may present very similarly to a person experiencing Obsessive Compulsive Disorder (OCD; Moldin & Rubenstein, 2006); however, a person with ASD seems to get pleasure and comfort from their repetitive behaviors and routine, whereas a person with OCD experiences discomfort and disruption from their repetitive behaviors (Leckman, et al., 1997).

### *1.2 Prevalence*

To understand the importance and necessity for treatment, the prevalence of ASD must be considered. It is also important to keep track of prevalence to determine whether the number of persons with ASD is increasing, decreasing, or staying constant (Centers for Disease Control and Prevention, 2009). Researchers have found it difficult to get accurate reports of the prevalence of ASDs because the diagnostic criteria for the disorders were not developed until 1980 (American Psychiatric Association [*DSM-3*], 1980) and have since undergone several revisions (American Psychiatric Association [*DSM-IV-TR*], 2000).

It has been confirmed that currently more children are being diagnosed with ASD than in the past and that the number has continued to rise between the years 2002 and 2006, with a current prevalence of 1 in 80 to 1 in 240 among different states (an average of 1 in 110 in the United States as a whole) (Centers for Disease Control and Prevention, 2009). Although it is unknown whether more children are getting the disorder, the

criteria is becoming more specified, or media attention is helping spread information, allowing for better awareness, the United States is facing a serious public health concern affecting about 1% of the nation's children.

The ratio of boys to girls who have autism, Asperger's disorder, and childhood disintegrative disorder is approximately 4:1 (Smith, 1997). Because of the gender differences in the prevalence of these disorders, genetic researchers have suggested a strong genetic component, due to the fact that girls are less likely to develop genetic disorders than are boys (Rutter, Bailey, Bolton, & Couteur, 1993). With Rett's syndrome, researchers have already identified the genetic component and have found that the X chromosome carries the genetic mutation. Because boys have only one copy of the X chromosome, if they have this genetic mutation, they will die in utero or shortly after birth. Girls, having two copies of the X chromosome, will survive with the result being Rett's Syndrome; therefore, the disorder is only seen in females. (National Institute of Neurological Disorders and Stroke, 2009).

### *1.3 Treatments*

The range of treatments available to a person with ASD is endless, all with varying effectiveness. Most people will try direct treatments, as well as combinations of treatments. Extensive research has gone into understanding the effectiveness of each treatment and it is important to consider the value of each in order to understand how society is coping with the disorders.

#### *1.3.1 Applied Behavior Analysis*

Applied Behavior Analysis (ABA) has been the standard practice for autism intervention for many years and it has been found effective under well-controlled studies,

which have allowed the dismissal of alternative explanations for the effects of the treatment (Maurice et al., 1996). ABA uses control of antecedent and consequence procedure, in the hopes that one can indentify the triggers of behavior, possible desirable behaviors to replace the disruptive ones, as well as the possible consequence that may be maintaining problem behaviors (Harvey, Wong, & Luiselli, 2009). If a behavior trigger can be identified, it may be possible to modify the child's environment in such a way that the trigger is no longer present. If incompatible positive behaviors can be found, it may be possible to eliminate the negative behavior altogether. Finally, if reinforcing consequences (i.e. escape, attention, avoidance, etc.) for negative behaviors are identified, the environment, including all persons present, may be modified to extinguish the reinforcing nature of the consequence (Martin & Pear, 2009).

ABA is most beneficial when it is used as an early intervention and as a rule of thumb, the earlier the better. Failing to provide early treatment of language delays may put a child with ASD at risk for deficits in other behavioral areas (Kelley, Shillingsburg, Castro, Addison, LaRue, & Martins, 2007). Along with the timing of the treatment, intensity is a key factor for the success of ABA. It has been recommended that a child with ASD undergo intervention for at least 25 hours each week, 12 months per year (Myers & Johnson, 2007). This need for frequent treatment underlines the possible role that online games could have in helping a child with ASD. Being able to augment their behavioral treatment with at home treatments could potentially reduce some of the time spent in expensive therapy sessions.

ABA has been found to be vitally and scientifically successful in the treatment of mental disorders, including ASD (Harvey et al., 2009), thus the current study's decision

to use ABA principles as the substantive basis for the design elements in the game. The following treatments are not fully substantiated by scientific research methods and therefore, should be considered in addition to, rather than in place of ABA.

### *1.3.2 Occupational Therapy*

Occupational therapy aims at training people living with ASD to do everyday tasks necessary for normal functioning. Some of the activities of daily living include dressing and feeding oneself, following safety precautions, and getting from one place to another. Also included in occupational therapy are recreational functioning, such as play and participation in social activities. With a child with ASD, the therapist will begin with an evaluation, which determines the essential behaviors for that specific individual and what will be taught in the personalized program. This includes collaboration between the therapist, the parents, and the child with the disorder. It aims to improve the quality of life for everyone in the household. The therapist will utilize the strengths of the child in the design of the program, avoiding processes that involve known challenges for the child. To achieve effectiveness of this type of intervention, only a skilled mental health professional should be utilized (American Occupational Therapy Association, 2006).

### *1.3.3 Sensory Integration Therapy*

The hypothesis behind this therapy is as follows; because individuals with autism are over (or possibly under) sensitive to different sensory stimulation (i.e. smells, sounds, tastes, textures, etc.), stimulating their senses in a meaningful and purposeful way can help to level out their levels of sensitivity. It is designed to be helpful with the proprioceptive system, which helps children know where their bodies are located in space, as well as the vestibular systems, which helps with balance, coordination, and eye

movements. The therapy has become widely known among the autistic community because of its seemingly common sense effectiveness. However, as cited by Maurice et al. (1996), research has not shown conclusive results as to the efficacy of using the treatment and many researchers believe it is simply a positively reinforcing stimuli, being that many sensory integration treatments include massage therapy and soothing music (Cermak & Henderson, 1990).

### *1.3.4 Gluten Free, Casein Free Diet*

Some researchers have suggested that the proteins in foods containing gluten and casein may negatively affect those with ASD because of their physiology, creating an excess of opioid activity. For this reason, diets free of gluten and casein have been hypothesized to reduce the behavioral symptoms of autism and the related disorders. Millward, Ferriter, Calver, and Connell-Jones (2004) conducted a literature review with the purpose of evaluating the efficacy of these diets as a treatment to improve functioning in individuals with autism (including behavior, cognition, and social skills). They found that no conclusive evidence could be drawn from the studies they evaluated, even though one study found a significant benefit in the treatment of autistic traits. Salley, Scarpa, and Fenton (2005) conducted a similar review of the literature, finding that only a "handful of studies" have evaluated these diets and have not found affirmative evidence for their efficacy in the treatment of autism. Therefore, it is recommended that clinicians avoid the sole use of elimination diets until more sufficient evidence beyond the anecdotal evidence is available.

### *1.3.5 Alternative Therapies*

Demonstrating the feeling of desperation that many parents feel overtime with unsuccessful attempts to help their child, many children are subjected to treatments with little to no supportive scientific evidence or research (Maurice et al., 1996). One example of these therapies in called holding therapy. Holding therapy aims to reduce the aggressive behavior in children with ASD, as well as children who are aggressive for other reasons (i.e. Oppositional Defiance Disorder, anger management issues, etc.). Although holding therapy has been found to be successful in the reduction of impulsive behaviors and aggression, most researchers agree that it should only be used as a tool when less intrusive approaches will not suffice (Bath, 1994).

Another alternative therapy is known as facilitated communication, which is a method intended to help the communication of nonverbal autistics. In this process, a trained facilitator holds the hands of a verbally impaired person on a keyboard with the intention of guiding typing, but not the actual communicated response. Much controversy lies around this technique and it was eventually discovered that the responses came from the facilitators, rather than the disabled themselves (Wegner, Fuller, & Sparrow, 2006). Overall, alternative therapies are many times the "last resort" for desperate parents in need of a solution for their child's disability, even if it is unsubstantiated with research (Maurice et al., 1996). This further demonstrates the need for options when it comes to ASD treatment. If it is not possible for a child to receive the full intensity of ABA in therapy sessions, there could be an option for less expensive, in-home alternatives, such as reproducible computer and video games.

### *1.4 Associated Costs*

Ganz (2006) has identified three types of costs associated with a person with ASD: nonmedical (i.e. productivity loss), direct and indirect medical, and human costs (i.e. reduction in quality of life). Taking all costs into consideration, it is estimated that about $35 billion dollars in total will be spent to take care of all individuals with ASD throughout their lifetime (about $3.2 million dollars per individual).

The direct cost of physicians, outpatient services, and clinical services per person each year is estimated to be about $1,896. It is estimated that prescriptions medications will cost between $166 and $295 a year, depending on disability level. Aside from physician visits, outpatient and clinical services, and prescription medications, a person with ASD will incur thousands of dollars a year on indirect medical costs including complementary and alternative therapies (CAM), hospital and emergency services, home health care, and medically related travel. Taking all direct medical costs into consideration, it is estimated that it will cost $29, 091 a year to care for a high-functioning child with ASD and $29, 569 a year to care for a low-functioning child with ASD (Ganz, 2006).

Ganz (2006) also reports nonmedical costs associated with caring for a child with ASD. Childcare for a highly functioning child can cost as much as $3,509 per year and as much as $6,502 for a lower functioning child (this estimate included children aged 3 through 22). Many children with disabilities will enter into special education programs costing about $16,128 per year (this estimate included children aged 6 through 21). Taking all nonmedical care costs into consideration, it is estimated that it will cost about $38,400 a year to care for a high-functioning child with ASD and about $43,750 for a low-functioning child with ASD.

The nonmedical cost of productivity loss can be seen as equal to what would have been acquired from opportunities missed as a cause of having ASD. The opportunities missed include both lost earnings of the person with ASD, as well as the people who care for them (i.e. quitting work to stay home with the disabled person). Ganz (2006) estimated, using average levels of earnings of the workforce in the United States and average level of supported work environments, that a person with ASD will forego between $41,779 and $59,498, depending on gender and level of disability, over a lifetime. He also estimated that parents/guardians of persons with ASD will forego anywhere between $39,000 to nearly $130,000 per year, an incredible amount.

In summary, Ganz (2006) has compiled a literature review and comprehensive study on lifetime costs of caring for a child with ASD, which begs for attention from governmental programs and researchers across the country. The lifetime cost of having ASD, per child, is over $3 million dollars. This is an incredible financial burden to those caring for the child and the household suffers as a cause of the disorder. Ganz (2006) hopes that his comprehensive research will help to direct focus on providing more resources, which can help in the search for prevention and treatment options. Aside from emotional, physical, and familial strife as a result of these disorders, the lifetime monetary cost of having a child with ASD simply cannot be ignored. The proposed design framework is not only a potential time-reduction tool, but could support and offer a system of tools to therapists, clinicians, and school systems at a lower cost than traditional methods.

### *1.4.1 Reduction in costs with ABA*

Jacobson, Mulick, and Green (1998) created a general model illustrating the reduction in costs when children with autism are given behavioral intervention at a young age, making a strong case for the early intensive behavioral intervention (EIBI). Their model was created through research suggesting the positive effects of EIBI, including the gain of skills in the areas of intelligence, academics, communication, social functioning, and daily living skills. They estimated that a gain in these skills could save a family anywhere between $187,000 and $203,000 per child between the ages of 3 and 22 years, and anywhere between $656,000 to $1,082,000 per child between the ages of 3 and 55 years. Although the initial costs of EIBI can be as high as $33,000-$50,000 a year, the estimated savings far outweighs this initial cost. Therefore, it is clear that EIBI is not only able to enhance the quality of life of a child with autism and their family, but can also reduce the lifetime costs of caring for someone with an ASD. This demonstrates yet another need for additional EIBI outside of the therapy sessions and it is possible that social skills games could offer this additional intervention.

## ***1.5 Research Objectives***

Research investigating less expensive, reproducible behavior management techniques and their effect on behavior and social skills in young children with autism is becoming a necessity in the United States considering the high prevalence, as well as the growing costs associated with the disorder. Not only are the costs high, there is also a matter of demand outweighing supply. With almost 1% of the population suffering from an ASD, there are simply not enough behavioral therapists and services to meet needs. One research objective here was to explore and develop a set of general design guidelines

for use in the future development of computer and video games as interventions in the treatment of ASD. A second objective of this study was to evaluate the ability of a computer game, as a design framework, to appropriately encompass validated ABA principles used in traditional face-to-face therapies in general, and more specifically in the augmentation of gaze following behaviors, a correlate of responding to joint attention, which, as presented in Section 2.1.2, plays a large role in language development. The information uncovered through this study aims to serve as a foundation for future developments in reproducible behavior management augments, as well as add to the very limited body of literature exploring computer and video games as innovative and alternative interventions for children with ASD.

# CHAPTER 2. LITERATURE REVIEW

## *2.1 Joint Attention*

In order to begin the design framework development, it was necessary to select a skill that the game would aim to improve in a child with ASD. Gaze following was selected and is a correlate to responding to joint attention. Joint attention is a skill that typically developing humans use each day without conscious awareness and probably take for granted. However, it is extremely important for the development of language, as well as functional social relationships. It is a skill that develops atypically in persons with ASD. Although this research aims to create general design guidelines and test the overall appropriateness of computer training in skills typically trained through face-to-face interactions using ABA principles; it was important to pick a specific deficit to follow through with as an example. Because of the possibly severe implications of a deficit in joint attention, this research believes it would serve as an excellent example and foundation for future research. It is also important to understand what it is, how it differs between the normally developing and the developmentally delayed, and how joint attention is currently trained through behavior management and assistive technologies (i.e. cognitive prosthesis, interactive online learning environments, etc.).

### *2.1.1 Defining joint attention*

Joint attention is a triadic skill, which involves two people and an object of interest. It is the ability to locate and direct attention to the same object or event that another person is focused on at that time (Scassellati et al., 2006). Scassellati et al. (2006) also mentions that it not a matter of chance that two people look at the same event or object, but rather a developed skill of gaze following, which is necessary for word

learning and language development. MacDonald et al. (2003) notes a young child will use both gestures of the body and eye contact to be able to coordinate their attention in this way. The person who points to the object or gazes at another person to get their attention is said to be "initiating joint attention (IJA)," whereas the person who looks at the referenced object or pays attention to the initiator is said to be "responding to joint attention (RJA)" (Adamson, Bakeman, Decker, & Romskil, 2009). Joint attention also includes what is known as a "gaze shift" between the person who has focused their attention on an object or event and the object or event itself and then back (MacDonald et al., 2006).

### *2.1.2 Role of joint attention in language development*

The correlation between the development of joint attention and the acquisition of language has been the subject of much research. It has been found that this skill is a "precursor to language development" (Murray et al., 2008). When infants believe their mother is looking at something that interests her, they note her head positioning at that moment and look around her for interesting objects. This skill of responding to joint attention occurs before spoken word. Around the time of the first spoken words, a child will begin to engage in the initiation of joint attention, which enables them to learn the names of objects that interest or surprise them (Murray et al., 2008).

Aside from observational evidence of word learning through joint attention, empirical studies have been conducted and found that a child's ability (or inability) to engage in joint attention was a significant predictor of future language skills (Mundy et al., 1990). Murray et al. (2008) points to several other studies, which all come to the same conclusion, triadic interactions including communicative pointing and gaze

following are the best predictors of future language development, as well as future vocabulary skill.

Joint attention is a skill that is deficit in children with ASD; therefore, its effect on language development presents differently than in typically developing children or in children with pure mental retardation. In fact, researchers found that 71 percent of children with general mental disabilities (i.e. mental retardation) could correctly map to a novel word and object through RJA, whereas only 29 percent of children with autism could do the same (Murray et al., 2008). The implications of this deficit in word mapping are extreme. If a child does not follow the speaker's gaze, they may direct their attention to the wrong object or event, thereby making correct and appropriate word learning nearly impossible. Children with ASD will either confuse words or simply never learn words in this manner, which as shown before, is the most significant way to develop language.

### *2.2 Joint Attention in Normal versus Autistic Development*

In normally developing infants, joint attention emerges between the ages of 6 and 12 months. Infants will continue to increase their ability to use this triadic skill over a period of a few months, until mastery is obtained around the age of one and a half years. Typically developing infants will begin to associate head pose of another person with an object or event of interest. This process begins as a "guess" made by the infant, which becomes reinforced with appealing consequences (i.e. a bird, a butterfly, an airplane, etc.) (Scassellati et al., 2006). By the time a child is about 14 months old, they will be able to reliably follow an adults' pointing behaviors to discover a hidden object, but only if the

adult looks at the child (engages in joint attention), not when the adult looks at his/her hand (Behne, Carpenter, & Tomasello, 2005).

Interestingly, because attention is a covert process, many of the constructs of joint attention are assumptions drawn from the physical act of behavior. If an adult points towards some stimulus and the child reacts by turning his/her head to look at that stimulus, we believe that the child is attending to both the stimulus and that the child is aware that he/she is attending to the same stimulus as the adult (Gernsbacher, Stevenson, Khandakar, & Goldsmith, 2008). As described in section 2.1.2, joint attention is vital to the typical language development of infants and children.

Autistic children will develop much differently in terms of joint attention and, in fact, joint attention is used as the most predictive item on screening instruments (Gernsbacher et al., 2008). For example, the Modified-Checklist for Autism in Toddlers asks parents, "Does your child ever use his/her index finger to point, to ask for something?," "Does your child ever use his/her index finger to point, to indicate interest in something?," "If you point at a toy across the room, does your child look at it?," etc. (Robins, Fein, Barton, & Green, 2001). Autistic children have been found to be less likely than typically developing children to use their index finger to point to something of interest or to turn their head in response to a parent's pointing; therefore, questions like these are considered to be diagnostic (Gernsbacher et al., 2008).

It is important to understand the differences in joint attention between these two populations, not only in terms of language development, but also, as Colombi et al. (2009) suggest, in the alteration of other developmental trajectories, such as cooperative

development. A deficit in cooperative development may prevent full participation in cooperative tasks, such as shared played activities.

### *2.2.1 Possible Causes of Atypical Joint Attention in ASD*

Early joint attention research focused its efforts on typical development in young children. However, there has been a shift and at the time of this research, more than half of the 150 articles found on PubMed examine joint attention within the autism spectrum and unanimously agree that children with ASD behave atypically both in responding to joint attention bids, as well as in initiating joint attention with another person (Gernsbacher et al., 2008). Because of this, as well as the importance of the skill in language development and cooperative skill building, researchers have begun to examine possible explanations for this deficit in joint attention.

#### *2.2.1.1 Covert Attention*

Covert attention is thought to be the neural process (i.e. internal) of focusing on one of several stimuli in the environment (Wright & Ward, 2008). In 1894, it was demonstrated that attention could operate without head movements and eye movements; therefore making the ability to be covert one of the fundamental laws of attention (Gazzaniga, Ivry, & Mangun, 2002). Gernsbacher et al. (2008) points to the use of covert attention as one of the reasons why joint attention might look different in autism, being that autistics score very well on measures of covert attention. In fact, it was shown that persons with autism score *higher* than typically developing persons of the same age range in terms of covert attention, supporting previous research showing that those on the spectrum tend to use and rely on peripheral vision. Therefore, Gernsbacher et al. (2008) suggest that the ability to participate in joint attention is intact in autism; however, it is

displayed covertly and atypically. A person with ASD may be able to see that another person has attempted eye contact and then looked at a stimulus through solely the use of peripheral vision, thus appearing indifferent, when in actuality; the person with ASD has followed the process and is more or less indifferent to the stimulus itself, not the process. Although this is only a hypothesis based on previous research, it demonstrates the possibility of certain skill sets being unknowingly present within those on the spectrum. Furthermore, this shows the potential to eventually uncover hidden skills within those on the spectrum's repertoire.

#### *2.2.1.2 Resistance to Distraction*

Another hypothesis set forth by Gernsbacher et al. (2008) is the following: Because individuals with autism are known for their incredible ability to resist distraction, as well as their ability to focus on an object of their choosing without end, their atypical presentation of joint attention is simply their ability to stay focused and resist the bids for attention from the people that surround them. This again suggests that children with ASD *can* engage in joint attention, but rather resist it. Gernsbacher et al. (2008) direct readers to results of a study conducted by Greenway and Plaisted (2005), which found that children with ASD will remain focused more than twice as long as normally developing children of the same mental age, and as much as four times as long as children with Down syndrome matched for chronological age. This research suggests the possibility that autistics have a stronger ability to resist the influence of social cues, as opposed to the idea that they simply do not understand or attend to them. If this hypothesis is indeed true, it may suggest the need for persons surrounding children with autism (i.e. parents, teachers, etc.) to change the way they bid for attention, as opposed to

the belief that children with autism simply *do not* have the ability to engage in joint attention (Gernsbacher et al., 2008). Using a game format has the potential to use different bids for attention and vary the rewards for participating in joint attention; thereby following the suggested direction of this type of research.

#### *2.2.1.3 Need for Causal Research*

Research has already made the shift from typical development of joint attention to atypical development of joint attention. Individuals with autism may perceive the world differently and now that it is understood that joint attention develops abnormally in ASD, as compared to typically developing children of the same age, researchers have the task of figuring out why it presents differently between the two groups. The causes of joint attention are not at the forefront of this study; however, the author believes that understanding the causes of atypical RJA and IJA behaviors is vital in using the proper intervention techniques. Therefore, this study suggests further investigation of the hypotheses set forth by Gernsbacher et al. (2008), as well as other researchers, in order to better develop effective intervention strategies.

### *2.3 Behavioral Training of Joint Attention*

In knowing the importance of joint attention for many other developmental skills, researchers have examined different training mechanisms and found that, although it is deficit, the underlying mechanisms for joint attention are present in the child's repertoire and can be taught (Naoi, Tsuchiya, Yamamoto, & Nakamura, 2008). It was necessary for the current study to select a skill in which ABA has already been shown effective in ASD intervention. This enabled the current study to apply already successful ABA principles, such that the augmentation of the skill was appropriately founded in previous research.

Being that computer games as social skill interventions for children with ASD are currently being researched, yet completed literature is extremely limited, it was necessary to utilize traditional face-to-face intervention research for the starting point of the game design. In the following section, three separate and successful behavioral interventions are discussed in the development of joint attention skills.

Whalen and Schreibman (2003) used a multiple-baseline design to evaluate the intervention effects of using behavior modification procedures. The target behaviors were as follows; 1) responding to joint attention (i.e. the showing, pointing, or gaze shifting of the adult), 2) shifting gaze in coordinated manner (i.e. with the adult), and 3) initiating joint attention (i.e. pointing to an object of interest with the intent of sharing, not requesting). The study evaluated 11 children (five with ASD and six typically developing children). The children with ASD were all approximately four years of age, while the typically developing children were between the ages of two and four years. Younger typically developing children were used to identify behaviors that are typical to preschool-aged children. The children with ASD had an average language-age of about 1.5 years, while the typically developing children had an average language-age of 2 years, 8 months.

Treatment for this study occurred in two phases. The first phase was entitled, "Response Training," during which the child was taught by the researchers to respond to bids for attention. The second phase was entitled, "Initiation Training," during which the child was taught how to bid for the joint attention of the researcher. Both phases were broken into levels, in which approximations of the behavior (i.e. responding when tapped hard, responding when tapped lightly, etc.) were reinforced until the behavior was

mastered. The researchers found that they were able to effectively train the target joint attention behaviors using the approximation method and that the target behaviors were transferred to other settings outside of the lab. The approximations that were found successful were mirrored in the current game prototype through the levels within the game. The skill to be taught, gaze following, was broken down to very simple in level one through more difficult and realistic in level three.

The researchers suggest that such positive results show the need for the integration of joint attention training into already existing interventions for autism. They also suggest continued practice of the skill outside of the treatment setting may help maintain what is taught during intervention (Whalen & Schriebman, 2003). The idea of continued practice in the home and outside of the treatment setting supports the need for the current research and the development of design guidelines for games and online environments for learning of social skills within this population.

In another study augmenting the skill of joint attention, Naoi et al. (2008) utilized a functional analytic approach to determine the controlling variables for initiating joint attention (IJA) behaviors and the underlying mechanism for the deficits of this skill in children with autism. Three children were used as participants in this study, all of whom met the DSM-IV criteria for ASD. The first child was 7 years, 5 months old, with a verbal mental age of 1 year, 11 months. The second child was 4 years, 11 months old, with a verbal mental age of 3 years, 5 months. The third child was 7 years, 11 months old, with a verbal mental age of 1 year, 6 months. According to the authors' use of the criteria found in the childhood autism rating scale, all three children were considered severely autistic.

The authors used a multiple-baseline design across the participants to evaluate the intervention effects. During the training sessions, the researchers manipulated antecedent events by utilizing the child's preferred materials (i.e. favorite toy, stuffed animal, etc.). The preferred materials were defined as the motivating operation for that particular child. The researcher would remain completely silent without any feedback, unless the child initiated a bid for attention of the researcher. If the child were successful in IJA, the researcher would immediately respond by looking at the child and the target, talking excitedly about it. If the child did not initiate a bid for attention, the researcher would say "bye-bye" to the target and it would disappear. Following training, the researchers found that functional joint attention behaviors were emitted more frequently, as compared to the baseline. The researchers conclude by suggesting that the deficits in IJA behaviors in children with ASD might be explained by their restricted interests, explaining why using preferred items increased IJA and using neutral items did not receive a response (Naoi et al., 2008). The current research considered these results in the use of positive reinforcement, as well as in the game format in general. Since children with ASD are known to have restricted interests and the study by Naoi et al (2008) supports the idea that this might affect joint attention skills, it is important to appeal to their interests during training. Although it is impossible to interest all children with ASD with one game design, the participatory design group was charged with and developed what they considered a game format that would appeal to many children with typically restricted interests (see Section 6.2.1).

Lastly, Isaksen and Holth (2009) produced and evaluated an operant training approach to teach joint attention skills for children with ASD, which was developed

based on relevant literature and current behavioral interventions. Similar to Whalen and Schreibman (2003), the researchers aimed at establishing joint attention in three main skills: 1) responding to bids for joint attention, 2) participating in turn-taking activities (while using joint attention training), and 3) initiating bids for joint attention. This study included four children with ASD as participants. The first child who participated in this study was 3 years, 8 months old. The second child was 4 years, 6 months old. The third child was 3 years, 10 months old. The fourth child was 5 years, 4 months old. Verbal mental ages were not noted in the paper; however, part of the inclusion criteria was that the child displayed a verbal mental age of *at least* 12-14 months of age. This criterion was developed because, in typically developing children, IJA and RJA behaviors would have developed by this time.

At the time of completion of this study, the training was novel in its attempt to establish an adult's head nod or smile as a conditioned reinforcer, as well as using tasks that were based on turn taking, thus utilizing and reinforcing both IJA and RJA behaviors. This was a within-subjects design where baseline measurements were compared to final measurements after treatment. The research found significant improvement in both IJA and RJA behaviors in all four children. Parental reports indicated that the training intervention generalized well to situations outside of the treatment area. The researchers suggest the power of the success of these results by noting the ease of maintainability. Smiles and nods as generalized reinforcers occur in daily life between children and their parents/guardians; therefore, it is easy for the child to exhibit the behaviors and continued to be reinforced (Isaksen & Holth, 2009), underlining the importance of generalization within ABA training. Because of both the

general understanding within the ABA community that generalization is key, as well as the results of the above study, the game prototype attempted similar forms of generalization. For example, as the above study utilized head nods, the game prototype utilized phrases that a child would typically hear in everyday settings when responding to joint attention (e.g. "Great, you also see the black bird that I am looking at!" etc.). Additionally, the final level developed a scene that mimicked a typical scene a child would encounter in day-to-day life. Although the generalizability of this game was not tested in the current exploratory study, it is something to examine further in future evaluations of the prototype.

The previous studies all showed support for the possible efficacy of behavioral interventions for training children with autism to initiate bids for joint attention, as well as responding to bids for their attention. It should be noted, interestingly, that aside from training children with ASD to use joint attention, it is possible to train robots to do the same. Scassellati et al. (2006) "trained" robots to not only exhibit social skills, but to also perceive and respond to these social cues. They use the perceptual system of the robot as a foundation for these cognitive skills, which are typically exhibited by humans. This is relevant to children with ASD because robotics can be used to help in the diagnosis and intervention of children who have ASD. Once the robot is able to recognize and respond to the deficit, it will be able to diagnosis a child with ASD, then move forward by attempting to train the child to use the same skills that the robot has been "trained" to use. This demonstrates yet another avenue that could utilize design guidelines which were produced by the current study.

### *2.4 Successful Use of Virtual and Interactive Training*

Werry, Dautenhahn, Ogden, and Harwin (2001) evaluated the role of robots as social mediators in autism therapy. Their aim was to teach children with autism skills that were basic for interaction in social situations. The researchers describe trials with two different autistic children and a robot. The situation demonstrated specific problems within the social context, as well as the strength of the children. Although the researchers acknowledged the need for further investigation, it was noted by the study that the "two-children-one-robot" scenario showed promising results for impacting social interaction skills of children with ASD. Understanding robotics as an alternative intervention for children with ASD is key to the innovative methodology of the current study. Expanding from traditional intervention techniques might be the key to uncovering more successful, cheaper, and easier to use methods that can reach more families and effectively assist more children with ASD. Aside from robotics, many researchers have evaluated the possibility of virtual and interactive environments in the training of autistic children, another innovate methodology, which is gaining support from some bodies of research.

Moore, Cheng, McGrath, and Powell (2005) conducted a study to determine if children with ASD were able to understand the basic emotions represented by a human-like avatar. Avatars are commonly used in an attempt to simplify the process of communication in virtual online worlds. Users, including those with ASD, are able to create their own avatar, as well as acknowledge the existence of other users by means of their avatars. The use of an environment with avatars for the facilitation of communication among children with ASD is proposed to be less threatening and simpler than real world interactions. It eliminates the need to understand subtle social cues, a

core deficit seen in ASD. The use of their collaborative virtual environment was found to be successful, giving additional support for the research objectives of the current study. However, it is important to note that one issue arose directly relating to the design of the game prototype developed in the present research. The researchers found evidence that children can understand caricature faces more easily; however, using more realistic faces helps in the transfer of skills learned to the real world. As previously noted, generalization is vital and irreplaceable in successful social skills training; therefore, it is more important than what caricature faces would provide, making human faces the selection over cartoon or other caricature-type faces.

Similar to the study produced by Moore, Cheng, McGrath, and Powell (2005), Konstantinidis, Luneski, Frantzidis, Costas, and Bamidis (2009) presented a framework for a semi-controlled environment that, rather than attempting to train social skills, was able to successfully assess social skills already present in the child's repertoire. This enabled behavior analysts, as well as parents, to devise a plan for intervention, acknowledging the strengths and weaknesses already present, as well as the controlling factors of each behavior, a key factor in creating successful teaching plans (Maurice et al., 1996). This study supports the idea that social skills can be demonstrated, and possibly augmented with the use of computer environments, as opposed to the traditional face-to-face treatment settings that, due to monetary or availability restrictions, are not always available to families of children with ASD. A game format, such as the prototype developed in the current study, could also be used in the same way that Konstantinidis, et al. (2009) envisioned: assessment of social skills, such that treatment plans can be developed and utilized more thoroughly.

Sitdhisanguan, Chotikakamthorn, Dechaboon, and Out (2008) present a study evaluating the efficacy of tangible user interface (TUI) in computer-based training of children with moderate-severe autism. The researchers used a participant pool of 16 children with ASD between the ages of 3 and 7. The experiment compared conventional means of training basic geometric shape matching to their proposed computer-based training mechanism. The results showed that those children who were taught geometric shape matching with TUI were able to learn more shapes than those in the conventional face-to-face training group, demonstrating strong support for the present study, utilizing innovative and creative interventions for this special population.

In terms of computer-based models for teaching, Moore and Calvert (2000) designed an educational software program, which was intended to mimic validated behavioral practices; however it differed in that it added salient qualities (i.e. sounds and object movement). They found that children with autism attended to the teaching program more and were more motivated to complete each task. This is suggested to have been the reason for the higher level of vocabulary acquired by those who learned through the computer program, as opposed to those taught in the behavioral program. The authors suggested that the results signify an implication for using computer software to teach children with autism. This study has given strong validity to the present study's choice of evaluating design guidelines for use in interactive game environments for the purpose of teaching gaze following (a part of RJA), as well as other social skills, as opposed to using only a behavioral program, in that increased attention and motivation facilitates learning.

Finally, Whalen, Liden, Ingersoll, Dallaire, and Liden (2006) evaluated TeachTown©, a computer-assisted instruction (CAI) program, which also utilizes ABA practices to teach different skills to young children with ASD and other developmental delays. The researchers found results similar to those found in the study by Moore and Calvert (2000). Children with ASD and other developmental delays were able to better learn appropriate social-communication skills, as well as reduce inappropriate behaviors through the use of the CAI program. From the above studies, it is apparent that there is a place for educational computer games in the instruction of young children with ASD.

The current study is novel in the development of a design framework for the training of gaze following, a skill that, to the best of the author's knowledge, has not yet been trained in this manner. Additionally, the current study has developed, through the evaluation of the design framework, a set of general design guidelines for computer-based social skills training games. Because of joint attention's vital role in language development, its ability to be successfully trained through behavior modification, and the success of previous researchers in training other social skills virtually and interactively; it is the belief of this research that joint attention, as well as other social skills found deficit in individuals with ASD, can be successful taught through these means.

# CHAPTER 3. EXPERIMENTAL GAME DESIGN AND DEVELOPMENT

Based on the previous discussion of the importance of joint attention in language development and the impact its deficit can have on the social growth of an autistic child (Section 2.1.2), this researcher has selected this skill as a starting ground for work on reproducible technologies, such as computer games, and the development of a general design framework, along with design guidelines. A number of researchers have already found success in this area (Moore et al., 2005; Konstantinidis et al., 2009; Sitdhisanguan et al., 2008); however, to this author's knowledge, the research has focused many of its efforts towards evaluating virtual environments, such as chat rooms, as opposed to computer games that aim to develop social skills. Because of the nature of the skill taught here and the anticipation of future success with other social skills, it is the belief of this research that a computer game could offer a great benefit to children with ASD.

Using the design guidelines found in this study with gaze following as the example, it is now possible to expand to further skills, continuing to base development on design elements already shown to be functional and useful. Also, by having successful interventions with easier access, at least as augments to behavioral treatments, it may help to provide additional ABA, thus slightly mitigating some of the high costs that are incurred throughout the lifetime of a person with ASD (Section 1.4). Therefore, the major engineering contribution of this research has been to develop a preliminary design framework along with design guidelines for future design of reproducible behavioral interventions (i.e. computer games), thus alleviating cost and time associated with current practices (further described in Section 6), as well as exploring the ability of this type of intervention to mirror ABA principles used in the traditional gaze following interventions

of children with ASD.

### *3.1 Creating Acceptance of Technology in Difficult Populations*

One of the first challenges in developing a technology for the autistic population addressed in this study was acceptance. Acceptance has been defined as a user's choice to engage in the technology presented to them (Madsen et al., 2009; Putnam & Chong, 2008). Children with ASD may be reluctant to engage in a new technology because, as noted earlier, individuals with autism thrive on routine and a new technology would be outside of their routine. Also, as noted by Gernsbacher et al. (2008), children with ASD have restricted interests; therefore, technologies that do not interest them may not be utilized to their full extent. For these reasons, the researchers of the present study examined literature, which aimed to uncover some of the mechanisms for creating acceptance in this population.

Madsen et al. (2009) conducted a participatory design session with adolescents on the autism spectrum. This was considered unique because many times persons with ASD are not involved in the design of the very technologies that are meant to help them. The researchers of this study learned and expressed three major design lessons. The first is the adaptation of the hardware's form. They discovered that the keyboard on their device would distract many of the participants; therefore, it was important to be able to hide this keyboard, thereby mitigating that distraction. This has implications for the present study because the keyboard is present, but will not be used (all required actions are "point and click."). For this reason, a suggestion will be made to the parents or therapists that if they notice the keyboard becoming a distraction (i.e. the child is playing with the keys or

staring at the letters), they should remove the keyboard from sight, either physically or by covering it with a cloth of some type.

The second design lesson involved was being sure to not overlay user interfaces. For example, in the original design, the researchers placed words on top of the face displayed on the user interface. This was found to be distracting to the users and was iteratively removed. The third and final design lesson mentioned by these researchers was to utilize expectation versus actual usage studies. For example, the designers gave the adolescents in their study the device without first giving instructions. They discovered that many times what was expected to happen was not actually the way in which the autistic participants utilized the device (Madsen et al., 2009). The current study was able to leverage these insights, thus learning from past design "errors." For instance, the researchers were careful never to overlap user interfaces, as well as to record demonstrated user expectations during each design evaluation phase, carefully noting if user expectations met the intentions of the game itself.

Putnam and Chong (2008) also aimed to evaluate what this population wanted from a design in their study. They explored their research question through the use of an online survey, probing participants about their experiences with technology-based products for people with autism, as well as their interests and strengths associated with technology. They found three main conclusions from their survey. First, it was determined that many of the respondents had not had any experience with technology that was designed for people with cognitive disabilities. This finding suggests that, although the technologies have been developed to some extent, they are very limited and also not readily available, at least in the case of the respondents of this particular survey.

The second major finding of the study was that participants reported the need for technologies that teach social skills, academic skills, and organization skills. This finding supports the choice of target skill to be taught in the present study, in that users with ASD are voicing a need, as well as a desire, for social skill advancement. The final finding of this survey is the interest of people with ASD in new technologies. Being that new technology was shown to be of interest to this population, it may strengthen the effectiveness of the present study's game prototype, in that it is a novel approach to ASD intervention.

Francis, Firth, and Mellor (2005) conducted a study with findings that paralleled the previously mentioned study: they agreed that participants could be successfully involved in the design process. However, they added some additional suggestions by acknowledging simple involvement of participants with ASD would not alone suffice in creating a successful technology. These suggestions are as follows: 1) There must be a trusting relationship between the designer and the user and 2) The designer should be experienced with ASD. Participatory design including persons with ASD was not utilized in the present study because of availability; therefore, the first suggestion is not applicable. However, the second suggestion directly applies to the designer of the experimental game in the present study. The designer has 9+ years of experience in working with this population and was able to utilize lessons from these years of experience in the structure and development of the game.

### *3.2 Why a Game?*

A game environment was chosen as the focus of this study for a few reasons. First, the research has had many years of experience working with children and

adolescents with ASD. Anecdotally, the experience has shown that this population, along with typically developing persons of the same age group, enjoy time spent playing both computer and video games. In fact, it has been the experience of the researcher that in many reward systems under token economies, Nintendo Wii ® and other game consoles were utilized as a reward. Past therapeutic use of video games, those of which were aimed for strategy and fun, not for skill building, has shown that video games offer both a confidence booster, as well as a calming mechanism for children with ASD (Griffiths, 2003).

In terms of usage, Huston, Wright, Marquis, and Green (1999) found that time spent playing video games increases in children with an increase in age, specifically, the amount of time spent of video games at age 5-7 is significantly higher than age 2-4. Video games in the study included Nintendo ® and Sega ®, as well as computer games. Time spent on other mediums, such as watching television, will decrease as video game usage increases, making video and computer games the majority of recreational technology utilized by this age group. Also, the researchers found that children engage in video games at a higher frequency on the weekends, than they do during the week. This was a factor in determining the possible efficacy for the use of video games in the current study because the weekends are a time when behavioral therapies are typically unavailable. Therefore, replacing some of the already played video games with ones aimed to increase social skills might help to augment and reinforce the therapies children receive during the week.

With the understanding that video and computer games are widely played by young children, it is important to understand the potential these games have in affecting

the behaviors of these children who play them. Anecdotally, some parents have been able to note changes in their child's behavior, based on playing video games. For example, Demarest (2000) cites therapeutic effects on her child after he begun to play video games. In terms of language, she notes that he is more readily able to discuss progress, give/follow directions, and ask questions, all of which are very important skills for any child. She also describes an improvement in basic reading and math skills. In fact, the first words that he could read were those from the video games he had played with frequency. Finally, Demarest (2000) describes the idea that because her son now had an interest that was popular with other children his age, he was able to improve on his social skills.

Empirically, studies evaluating the ability of this medium to affect general social behavior in the typical population support the idea of a potential benefit. For example, Greitemeyer and Osswald (2010) found that video games are able to influence a child's behavior both negatively and positively. First, they reviewed literature that cautioned parents about allowing their children to play violent video games because these types of activities can lead to higher levels of aggression, as well as a more negative attitude. The conclusions of such literature led the researchers to create the hypothesis that, if children could be negatively socially influenced by video games, they could also be positively influenced, an important hypothesis considered in the creation of the current game prototype. Through their study, the authors illustrate the potential video games have to be successful in bettering a child's behavior. For example, they found that participants who engaged in a pro-social video game were positively influenced by what they had done in the game, and thus were more likely to offer assistance to those needing it in an

accident or mishap of some sort. They also found that the same participants who played the pro-social video game were more likely to assist in further experiments, devote more time to the experiments, and to intervene in a situation where another person was being harassed. From this study, it is fairly obvious the effect that playing a video game devoted to a certain type of behavior (i.e. pro-social, proactive, aggression, violence, etc.) can have on a person, be it positive or negative. This helps to augment the perceived benefit of the design guidelines produced by this study, which aim to enrich future computer games in such a way that there is an increase in the social behavior selected by using tools such as positive reinforcement.

Additionally, studies have shown support for the effectiveness on skill building in children with ASD, as well as other developmental disorders, when utilizing a video game, computer game, or computer assisted instruction. For example, Okolo (1992) conducted a study, which examined the effect of computer-assisted instructional (CAI) programs on the math skills of learning disabled children. The researcher found that students scored higher on the problems that had been practiced through the CAI program, as opposed to traditional methods. This study further supports the possible benefits of utilizing innovative technologies for children who are developmentally delayed, as opposed to only traditional methods.

Showing the effects of gaming on cognition, Basak, Boot, Voss, and Kramer (2008) investigated the effects of playing a strategy-based video game on the cognitive decline of older adults (~70 years of age). Although participants were typically developing and much older than the target population of the current study, it is important to view the ability of video games to affect cognition in general, further demonstrating

the potential of video games in the social skill augmentation of children with ASD. Basak, et al. (2008) concluded several pertinent and relevant points. First, they found significant beneficial effects of playing the video games on the executive control functions in their participants. Participants were better able to transfer from task to task, as well as balance different tasks successfully that relied on working memory. Second, they found that participants were more readily able to make decision based on strategy and resources currently available. Finally, individual differences in game performance improvement were correlated with individual differences in task-switching improvement. This might suggest that a video game is more effective for those who learn the game better than those who may not be as versed in the game. This study shows that cognitive abilities can be augmented through the use of game play, and it also adds an interesting notion that, video game efficacy may vary from individual to individual. This means it is important for the game to be challenging enough that it remains interesting to a child with ASD; however, it must be easy enough to learn, such that cognition can be affected and social skills learned.

*So, in short: why a game?* A game was chosen as the intervention here because children of many different developmental capabilities are shown to enjoy them and play them more often with an increase in age (Huston, et al., 1999). It is believed that computer and video games will be an effective supplemental activity to behavioral interventions that can be engaged with independently. Finally, as shown above and in Section 2.4, researchers have suggested the possible influences video and computers games can have on both behavior and cognitive ability. This medium has the potential to be recreational and educational at the same time. This offers the child some

independence in his/her learning, as well as an inexpensive behavioral "tool" in which parents can engage their child.

### *3.2.1 Theoretical Grounding*

Video and computer games as interventions for ASD is a relatively new topic in research and literature is limited in terms of efficacy on teaching individuals with ASD in this manner; however, anecdotal evidence shows that many children with ASD enjoy both video and computer games. Also, to the knowledge of this author, researchers have not attempted to develop joint attention, along with many other pertinent social skills, in children with ASD outside of behavioral therapies. Because of these novel aspects of this type of research, certain validated behavioral principles were utilized to limit the number of "new" variables. To the researcher's experience, the following principles were typical in traditional ABA interventions and provide a more solid and founded groundwork for the game/iterations and each evaluation.

#### *3.2.1.1 Positive Reinforcement*

A positive reinforcer is defined as "an event that, when presented immediately following a behavior, causes the behavior to increase in frequency (or likelihood of occurrence)" and is "roughly synonymous with the word reward." Therefore, it follows that positive reinforcement states that "if, in a given situation, somebody does something that is followed immediately by a positive reinforcer, then that person is more likely to do the same thing again when he or she next encounters a similar situation" (Martin & Pear, 2009; Lovaas, Schriebman, & Koegel, 1974).

As shown in Section 1.3.1, ABA has been shown to be successful in extinguishing troublesome behaviors, as well as increasing desirable behaviors. One of the key

components of ABA is identifying consequences to an action and its influence on the maintenance of the behavior (Harvey et al., 2009). Therefore, this research has chosen to capitalize on this principle and add elements of positive reinforcement, as well as make this a large focus during the participatory design group. Whalen and Schreibman (2003) utilized the same principles of positive reinforcement in their behavioral training of joint attention and found that by rewarding each approximation of the behavior, they were eventually able to train this skill. The ability to train the skill shows that children with autism are able to engage in this behavior, an important criterion in selecting this skill as the groundwork for the design guidelines.

The same researchers also suggested the increased effectiveness of continuing to practice skills outside of a treatment setting; therefore, applications such as the current game could help to maintain behaviors that are being taught in therapy, leading to more beneficial interventions. In looking at reinforcement, the timimg of the reinforcement must be considered. Following the definition of positive reinforcement, Sitdhisanguan et al. (2008) showed that real time feedback stimulates the most learning and generates the most attention from children with ASD. For this reason, the present study has included immediate reinforcers for correct responses, as well as delayed general reinforcers for completing each level.

*3.2.1.2 Generalization*

Generalization, in terms of this study, is defined as the trained behavior, engaging in joint attention, specifically gaze following, transferring from the training environment (i.e. the computer game) to the natural environment (i.e. other humans the child encounters in day to day living) (Martin & Pear, 2009; Lovaas, Schriebman, & Koegel,

1974). The literature is torn on the issue of using cartoon avatars or realistic human faces in the training of skills for children with ASD. In fact, Cheng et al. (2005) demonstrated that children with autism are able to understand the emotions and actions of caricature avatar faces, such as Homer Simpson, more easily than human faces. However, the same researchers also found that the use of more realistic human faces helped to generalize to the outside environment. Because generalization is one of the main goals of the present study, otherwise the training would have no practical significance; real faces have been chosen as the characters within the design.

*3.2.2.3 Fading*

Martin and Pear (2009) refer to the definition of fading as given by Deitz and Malone (1985): "the gradual change over successive trials of a stimulus that controls a response so that the response eventually occurs to a partially changed or completely new stimulus." Fading is considered an effective technique for directing behavior to occur in such a way that will eventually allow for independent exhibition of the behavior. For example, Lavigne (1992) investigated the efficacy of self-modeling and stimulus fading in an attempt to get an electively mute child to begin speaking. The child in this study remained mute only when in a school setting. The researcher used a stimulus fading procedure, which involved getting the child to speak at closer and closer approximations of a school setting (i.e. an empty room→a room with only school books → a room with school books and her best friends, etc.). It was found that this procedure was able to facilitate the communication of the child in the study and the author concluded that fading is an effective means of behavior modification. The fading procedure used in the

current prototype was modified each time during iterations of the design and the final fading design guideline is provided in the Results Section.

### *3.3 Development*

A user-centered design process, as offered by Weissenberger and Thompson (2009), was utilized in the development of this design framework with included a step-by-step iterative evaluation of the game prototype.

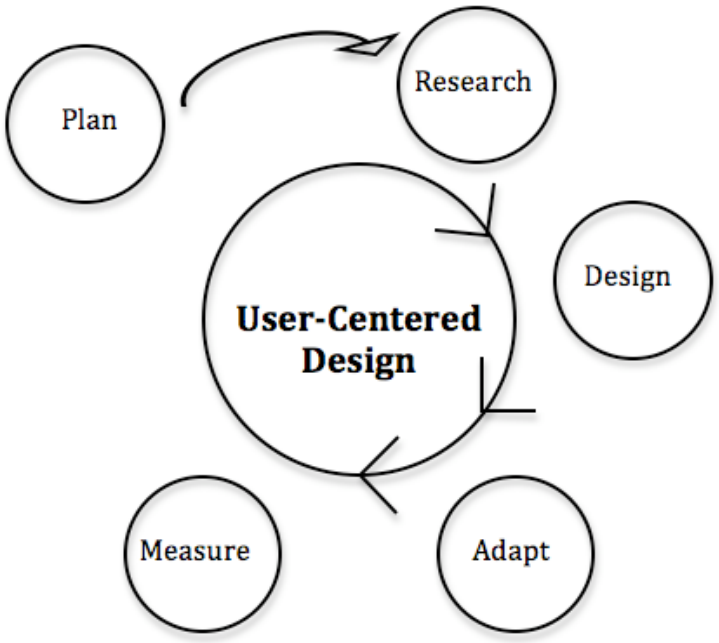


*Figure 1: User-Centered Design Process*

#### *3.3.1 Planning Stage*

First, the planning stage was needed in which 1) need for research, 2) key stakeholders and 3) limitations were identified. The concept of training joint attention was found to be in need of further research and alternative intervention methods from a search of "hot topics" in autism. Joint attention has only recently been pointed to as a source of language deficit in children with ASD. Also, looking at overall lifetime costs of having ASD, it is evident that there is a need for cost mitigation, possibly through means of innovative interventions and harnessing the power of new technologies.

The key stakeholders are first and foremost the children and adolescents with ASD and their families. Life is much more complicated for those living with ASD, either personally or caring for someone with ASD, and methods to treat this disorder need to be created to help alleviate these complications. Additional stakeholders include both therapists and clinicians that might harness these technologies in the future, as well as the research community, which will be able to use this design framework and this new technique of intervention in the development of other social skills games. One of the main results of this study was the production of a set of general design guidelines and a design framework, such that interventions of this type can be utilized for a wide range of social skills training.

In general, the known limitations associated with this population are:

- Limited and difficult to access population
    - This was not an issue at this stage of research development; however, it is an ultimate goal of this research to evaluate the game with children with ASD to detect if the developed computer game can improve gaze following. At that time, this limited and difficult to access population may pose certain issues that will make recruitment challenging.
- Difficult access to experts in the field of technology and autism
    - Because the interdisciplinary nature of this work is newly studied, it was noted that it would be difficult to find experts in the field. However, it was found not to be impossible. This type of work is being done, it just takes some extra steps to find those involved.

- Abundance of anecdotal evidence, but a lack of empirical research on social skills games and video games in this population.
    - The literature for computer and video game interventions for children with ASD is limited and incomplete. At the start of the study, it was noticed that the studies are being conducted currently; however, completed and published studies are few and far between. This created the need to find studies on ASD interventions and studies on video games, examining them concurrently.
- Large variance in ASD presentation.
    - As stated in Section 1.1, children with ASD lack evidenced biological and genetic causes for their disorder; therefore, behavior is the only measurable factor and because of the inherent variability, it is impossible to devise one solution for all children with ASD.

### *3.3.2 Iterative Design Stage*

RESEARCH. Next, the research stage involved looking at previous research and incorporating the ABA principles, which have already been proved effective to at least some degree in most children with ASD. This research laid the groundwork for the design of the 1st iteration, which was developed as a paper prototype that could be easily modified to encompass newly encountered information.

DESIGN. The original design of the program incorporated using a "click" response to an event to initiate joint attention (IJA) of the avatar on screen. For example, an object would appear on the screen, and the user would be expected to click on the object, showing the avatar that he/she has become aware of it. However, it was

determined that a click response does not mimic closely enough the natural IJA behaviors, which would include pointing or gaze shifting.

ADAPT. The next step in user-centered design, called for an adjustment of the framework. It was determined that the most efficient change would be to select a different element of joint attention, specifically responding to joint attention (RJA). RJA includes gaze following and shared attention; however, to limit the scope of this study, as it is only exploratory in nature, the gaze following portion only was targeted.

DESIGN. Once the prototype was refined in support of the new criteria, a computer science student with 10+ years of experience in programming was consulted. This student developed a functional prototype with Macromedia Flash® (v. 8) that, once completed, was given to a Board Certified Assistant Behavior Analyst (BCaBA) at the university for additional evaluation in terms of ABA frameworks.

MEASUREMENT. In this 1st functional prototype, an object would appear on screen and the game character would either look congruently (i.e. at the object) or incongruently (i.e. away from the object). The BCaBA determined that this would not be an appropriate training device considering the focused attention limitations and behavioral capabilities of young children with ASD.

ADAPT. A new prototype was developed with Macromedia Flash® (v. 8) which contained a plain background, along with four stagnant circles around a figure. The child's goal is to determine which circle the figure is looking at. An example of this concept follows:

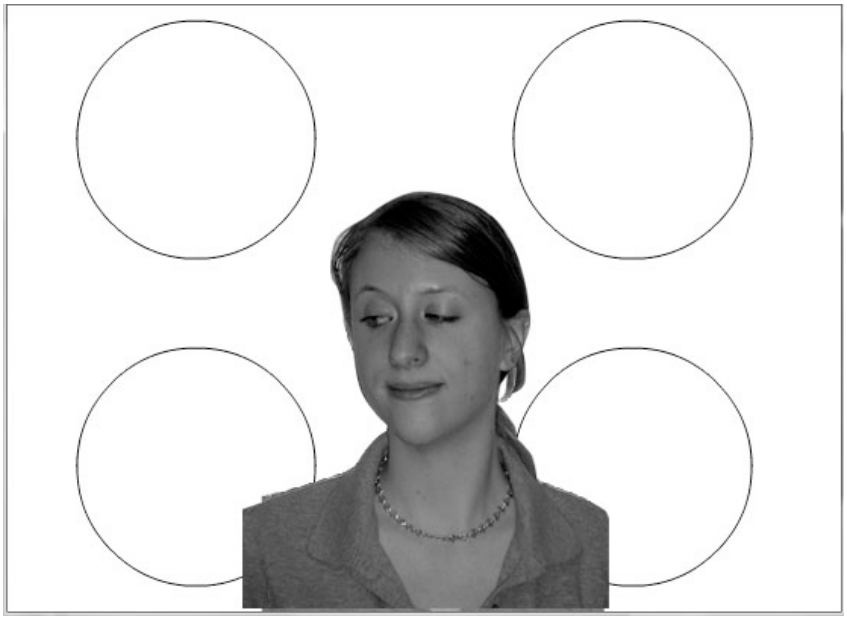

*Figure 2: Prototype Presented at CHCI*

MEASURE. This prototype and the study's procedure were presented at the Center for Human-Computer Interaction (CHCI) at Virginia Tech Student Speaker Series. Here, the researcher gather feedback from HCI students and professors on both the game design during that phase of development, as well as the aptness of a game format in translating ABA principles into computer-based interventions for ASD. From this feedback, slight changes were implemented resulting to the following:

ADAPT. A 3rd iteration was created based on some of the general comments were made in the previous stage of measurement. A more formal process of evaluation was used to measure effectiveness, efficiency, and satisfaction (Weissenberger & Thompson, 2009), three elements deemed to be important for success of a training method.

MEASURE. Formative evaluation was used to measure these constructs. As stated in the limitations, experts in the field of ASD and technology are difficult to come across. Because these experts were not readily available at the study's home school, the

researchers called upon Dr. Gregory Abowd, a distinguished professor at Georgia Institute of Technology (Georgia Tech) and an expert in the field of technology and autism, as well as Dr. Agata Rozga, a developmental psychologist with a specialty in autism. Both of these professionals are knowledgeable in the cross of the engineering and psychology fields. The researcher received feedback both from the above professors, as well as the Technology and Autism class at Georgia Tech. The graduate students in the class were treated as Subject Matter Experts (SMEs) in a focus group setting and were able to point out both technical issues, as well as possible confounds within the game that might make it difficult for a person with autism to use. For example, the use of only one person as the subject of design left limited variability, thus increasing the possibility of boredom with the use of the game by a child with ASD.

Although the study was unable to use persons with ASD during the participatory design group as desired, the game did receive a small level of exposure to the target population. During the evaluation at Georgia Tech, an adult with ASD, was present and produced input as a user in regards to the satisfaction with playing the game. One of the main concerns that the adult voiced was that the model, as shown in figure 2, was a female, considering the overwhelming majority of boys in the autism population.

ADAPT. As a result of this finding, the developers incorporated an option for the child to select which photo he/she would like to use (a male/female adult or a male/female child). This should enrich the child's experience, as it will be individualized and, as the child becomes more comfortable with the game, it will add variety.

SUMMARY. Overall, the game design has seen the guidance of Katrina Ostmeyer (BCaBA) and the Center for Human-Computer Interaction, both facets of

Virginia Tech, as well as Dr. Gregory Abowd, Dr. Agata Rozga, the Technology and Autism class, facets of Georgia Tech. The final prototype used in evaluations and the participatory design group through which the final design guidelines were developed was presented at George Mason University during the Human Factors and Ergonomics Society Student Chapter Symposium. Fifty students and professionals in the field of engineering and technology were present, and although minor technical issues were addressed, overall it was determined that the game would be effective and efficient for use in development of the final design guidelines. Please see Figure 3 below for a visual summary of the game development process, as described above.

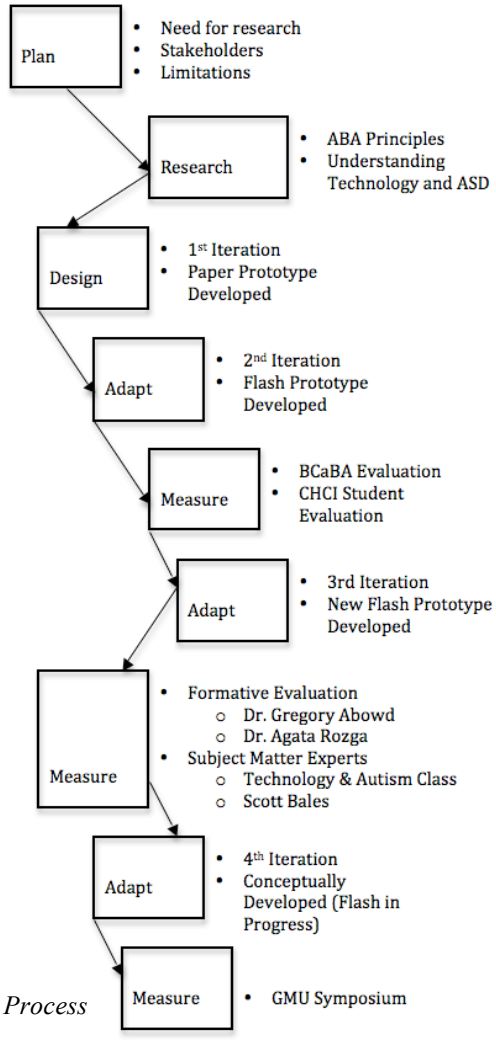


*Figure 3: User-Centered Design Process*

### *3.3.3 Element Design Stage*

Concurrent to the game prototype design stages, it was necessary to select conclusive design of a few elements, those of which would not be affected by other design correlates (e.g. photo selection, timing, etc.). First, with the use of multiple photos engaged in gaze tasks, it was necessary to ensure that the photos accurately depict eye-gaze direction. Ten independent coders were asked to look at each of the pictures during the gaze task and determine direction of eye-gaze. Only photos that were unanimously agreed upon were added into the final prototype design.

Next, it was necessary to select a time limit for engagement in the game. This was found to be a challenging correlate to this study. The more extensive and intensive an intervention is, the more beneficial it tends to be. Therefore, at the onset of development phase, it was decided that the game would be designed such that the child would play for an extended (i.e. 30 minute) period of time. However, upon further review of relevant literature, it became clear that 30 minutes was too long for a child with ASD to properly attend to the game. As stated previously, attention is a key correlate to gainful play. Ruff and Capozzoli (2003) found that, although focused attention significantly increases and casual attention significantly decreases in children as they age, focused attention still spans only about a minute in 4-year-old children. Garon, Bryson, and Isabel (2008) found similar results in their review, which included children as old as 6 years, matching the target population of the present study.

For these reasons, the researchers chose to design the game with the goal of 10 minutes of game play each time the child engages. It is the belief of the researchers that the positively reinforcing stimuli will serve as a "break" from focused attention, which

will allow for longer play. Additionally, Thiemann & Goldstein (2001) found success in their behavioral training program with 10 minutes per skill taught over 30-38 trials. The game is designed such that it can be played "at will," therefore, if the child highly enjoys the game, they could play it multiple times per day, increasing their exposure to the social skills training.

Finally, the presentation of instructions was considered. In accordance with attention capabilities in young children, Hale, Taweel, Green, and Flaugher (1978) found that until 8 years of age, children are not able to divide their attention between the task at hand and instructions being presented. For this reason, the current design, which is aimed at children 4-6 years old, includes instructions given at a time when nothing else is required of the child except to listen, thus maximizing the likelihood that the child will focus on the directions without becoming overwhelmed or distracted.

### *3.4 Summary of Final Prototype Design for Evaluation*

In every level of the game, the person engaged in the game, hereby referred to as the "player," is greeted by a welcome screen, which prompts him/her to select the photo with which they want to engage (from left to right: a male adult, a female child, a male child, or a female adult):

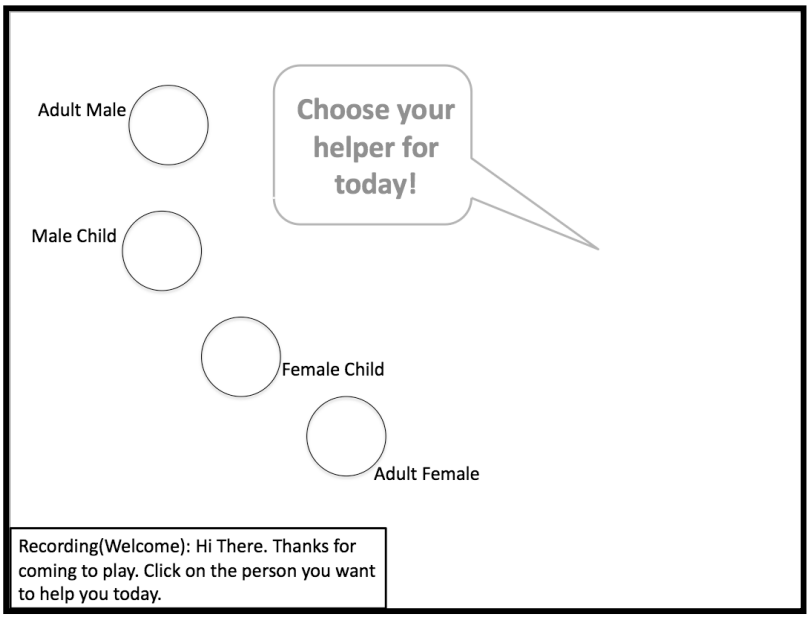


*Figure 4: Conceptual Representation of Welcome Screen*

The player is then asked to choose the level that they were most recently on; Level 1 if they are just beginning. This is stated visually and verbally:

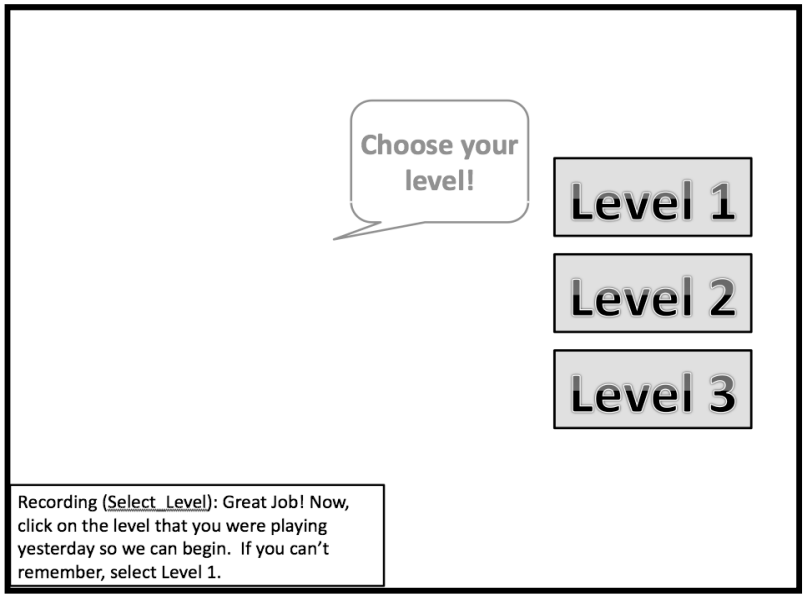


*Figure 5: Conceptual Representation of Level Selection Screen*

### *3.4.1 Level 1*

In the first, most basic, level of the prototype, there is a photograph (selected by the player) in the direct center of the screen who is surrounded by 4 circles of the same

diameter, all of which are equidistant from the figure (one in the upper-right, one in the upper-left, one in the lower-right, and one in the lower-left), representing the four directions in space around the figure. The photo is of a human in color for generalization purposes, as described in section 3.2.1.1. The photo changes in terms of eye gaze direction only, looking at one of the four circles on the screen.

The player is directed to click on the circle the person in the photo is looking at. Vocalizations give the player instructions on how to play the game, "Click on the circle that I am looking at," as well as provide feedback, "No, that wasn't the circle I was looking at," or "Yes, you got it!" When the player clicks on the correct circle, a voice reinforces the player by telling him/her that they answered that round correctly. Additionally, the scoreboard will show a gain of one point. The aim is to use positive reinforcement, as described in Section 3.2.1.2, to teach the player that they will be rewarded for following the gaze of another person. In general terms, this aims to teach the child the concept that, when someone looks with intent in a certain direction, there is most likely a reinforcer there (i.e. some interesting event or object).

When the player answers incorrectly, they are verbally corrected and one point is subtracted from their current score. An example of the Level 1 screen follows:

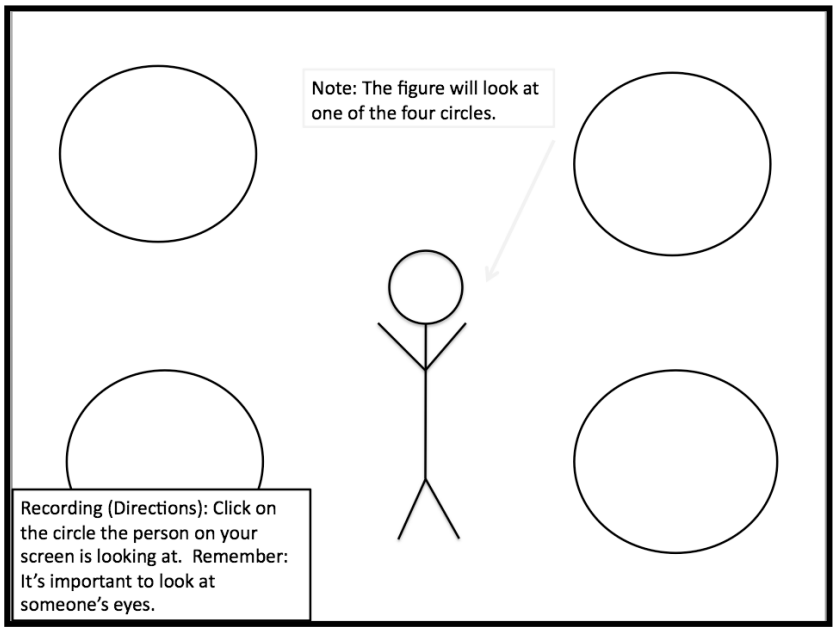


*Figure 6: Conceptual Representation of Level 1*

Fading, as described in Section 3.2.1.3, is used to guide the player to the correct circle (i.e. the one the figure is gazing towards versus the other three circles) as he/she becomes acclimated to the game. The intention is that parental instructions will not be needed (Martin & Pear, 2009), thus establishing a sense of independence in learning for the child. After the figure in the center looks at one of the circles, that circle will flash in black, directing the player's attention to the circle the person in the photo is looking at. If the child clicks on the correct circle, the flash will occur for a shorter period of time. The flash will fade by becoming shorter for each of 5 consecutive correct trials, until the flash is no longer present. If the child clicks on the incorrect circle, the flash will again appear, but for the shortest amount of time (only going back one step). If the child clicks again on the incorrect circle, the flash will become darker (going back another step), and so on:

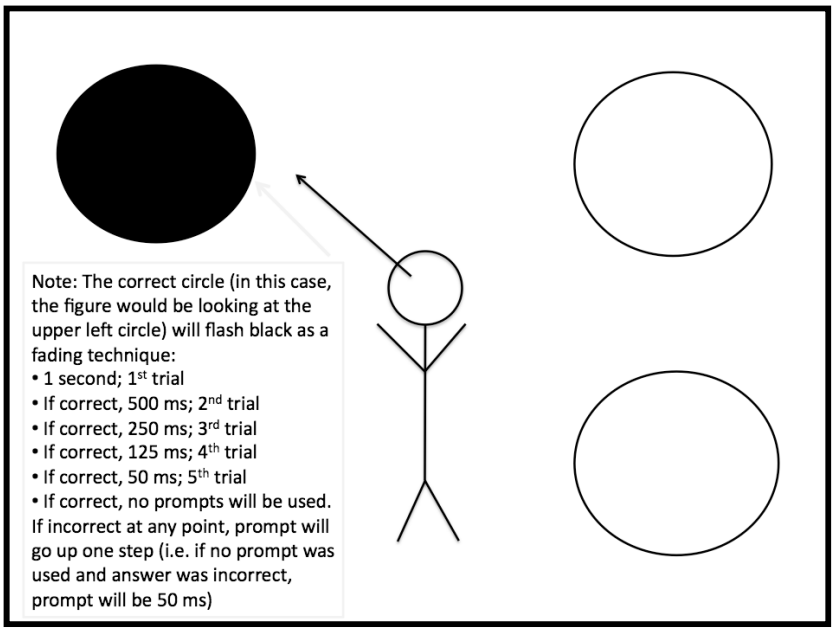


*Figure 7: Conceptual Representation of Fading Mechanism*

The game has a self-timer, which runs for 10 minutes, and when the timer runs out, another vocalization will provide a recap of what the child has done, as well as a reminder to come back and play the following day.

### *3.4.2 Level 2*

In the second level of the game prototype, there is again a photograph of human, selected by the player, in the direct center of the screen, surrounded by 6 circles of the same diameter. In this level, the circles appear in equal spacing around the face of the character. The larger number of circles adds to the level of difficulty and creates a significant change in routine from the first level of play. The photos are of the same models used in Level 1 and change in terms of eye gaze direction only.

The player is directed to click on the circle the person in the photo is looking at. Vocalizations give the player instructions on how to play the game, "Click on the circle that I am looking at," as well as provide feedback, "No, that wasn't the circle I was looking at," or "Yes, you got it!" Again, when the player answers incorrectly, one point is subtracted from their current score, and when the player clicks on the correct circle,

one point is added to the scoreboard to reward them for eye gaze following. The aim is ultimately to use positive reinforcement, as described in Section 3.2.1.2, to teach the player that when someone looks with intent in a certain direction, there is probably something reinforcing there (i.e. some interesting event or object):

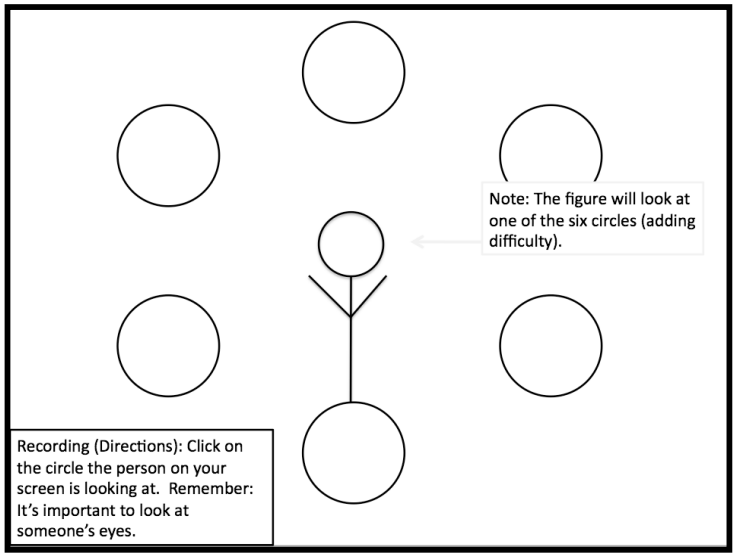


*Figure 8: Conceptual Representation of Level 2*

Fading, as described in Section 3.2.1.3, is used in the same manner as in Level 1. The game has a self-timer, which runs for 10 minutes, and when the timer runs out, another vocalization will provide a recap of what the child has done, as well as a reminder to come back and play the following day, starting with Level 2.

### *3.4.3 Level 3*

In the final, most difficult, level of game play, a photograph, as selected by the player, appears on the screen. The figure appears in a different area on the screen and a real world scenario is depicted where gaze following would be appropriate. Specifically, the figure is shown at a picnic with two different juices (i.e. cranberry and orange) placed on the table to the left, two different birds (i.e. one black and one white) in the sky to the left, and two different weather elements (i.e. a sun and clouds) to the right. The eyes

"point" to and a prerecorded voice asks for the object, mimicking an everyday situation in which the use of hands might not be available. The prerecorded voice also provides feedback, "No, that wasn't what I wanted" or "Yes, you got it!" When the player clicks an incorrect item, they lose one point from their current score. When the player clicks on the correct item, they gain a point as a reward for eye gaze following:

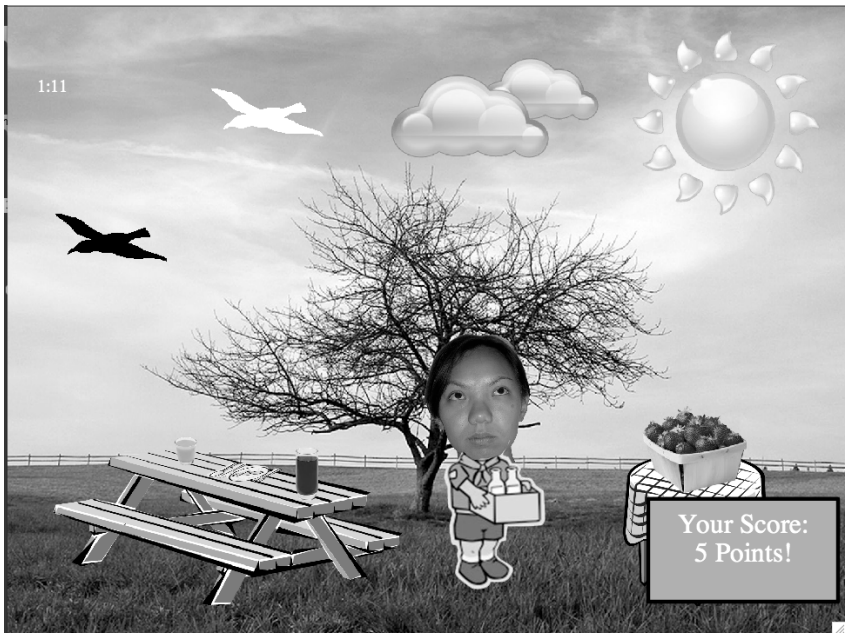


*Figure 9: Screenshot: Functional Prototype of Level 3*

Fading, as described in Section 3.2.1.3, is used in the same manner as in Levels 1 and 2. The game has a self-timer, which runs for 10 minutes, and when the timer runs out, another vocalization will provide a recap of what the child has done, as well as a reminder to come back and play the following day, starting with Level 3.

### *3.4.4 Changing Levels*

At the advice of the BCaBA and the experience of a class entitled, "Behavioral Intervention for Young Child with Autism," the game has been designed such that once the player has accumulated 30 correct answers; he/she will be able to move on to the next

level. Thirty is a generally accepted number of correct trials in ABA intervention and because this study is following ABA closely, this has been deemed appropriate.

At the completion of each level, a more extensive positive reinforcer is provided. A visually and verbally stimulating screen provides the option of two short videos that the player can watch as a reward for completing each of the two levels

### *3.4.5 Target Design Population Specifications*

Children with a diagnosis of Rett's Disorder were not considered as a part of the target design population because, unlike other disorders on the spectrum, there are clear genetic markers for Rett's Disorder (National Institute of Neurological Disorders and Stroke), as well as a much different presentation of the disorder. Children with Childhood Disintegrative Disorder were also not considered because, as described in Section 1.1.3, children with this disorder will continue to regress in many areas, as is not the case with other disorders on the spectrum. This creates the need for a different approach to social skill augmentation, one with which the researchers were not familiar.

The study's design focused on an age range of 4-6 years old following the successful results of using computer-training methods on children 3-7 (Sitdhisanguan et al., 2008), as well as the findings that around this timeframe, this age group generally begins to have an increased level of using video and computer games (Huston et al., 1999), and therefore might be more familiar with the general mechanisms. In terms of level of functioning, a clinician or therapist considering this type of intervention, as well as the evaluators of the game prototype, described further in Chapter 5, should aim for children with a mental age of at least one year and up to three and a half years, based on traditional training of joint attention (Naoi et al, 2008; Whalen & Schriebman, 2003).

Because gaze following has not yet been trained through the use of innovative technology, designating a target level of functioning was difficult and a possible limitation of the current study. Once the game has been fully developed, it would be beneficial to evaluate with children, to set more firm guidelines in terms of both physical and mental age (as a measure of level of functioning).

## CHAPTER 4. RESEARCH QUESTIONS

The present study was concerned with developing a set of general design guidelines for use in the development of computer and video games as interventions in the treatment of social skills deficits found in Autism Spectrum Disorder (ASD). Additionally, the study looked at a computer-based game design and the degree to which it appropriately encompassed the validated ABA principles used in traditional face-to-face therapies both in general, as well as specifically for the augmentation of gaze following behaviors, a correlate of responding to joint attention.

The two major research questions addressed by this study are as follows:

**RESEARCH QUESTION 1: In regards to the basic elements of a computer-based gaming system for children with ASD, what are the design guidelines that help facilitate successful development of the intervention?**

**RESEARCH QUESTION 2: To what extent does this game format appropriately mirror the ABA guidelines and practices used in the intervention of children with ASD, specifically in terms of gaze-following behavior augmentation, a subset of RJA training?**

## CHAPTER 5. METHOD

As described in Section 3.3, the game prototype was developed systematically to provide the most viable groundwork for the subsequent evaluations and the final design guidelines. The following chart summarizes the flow and method of the study entirely:

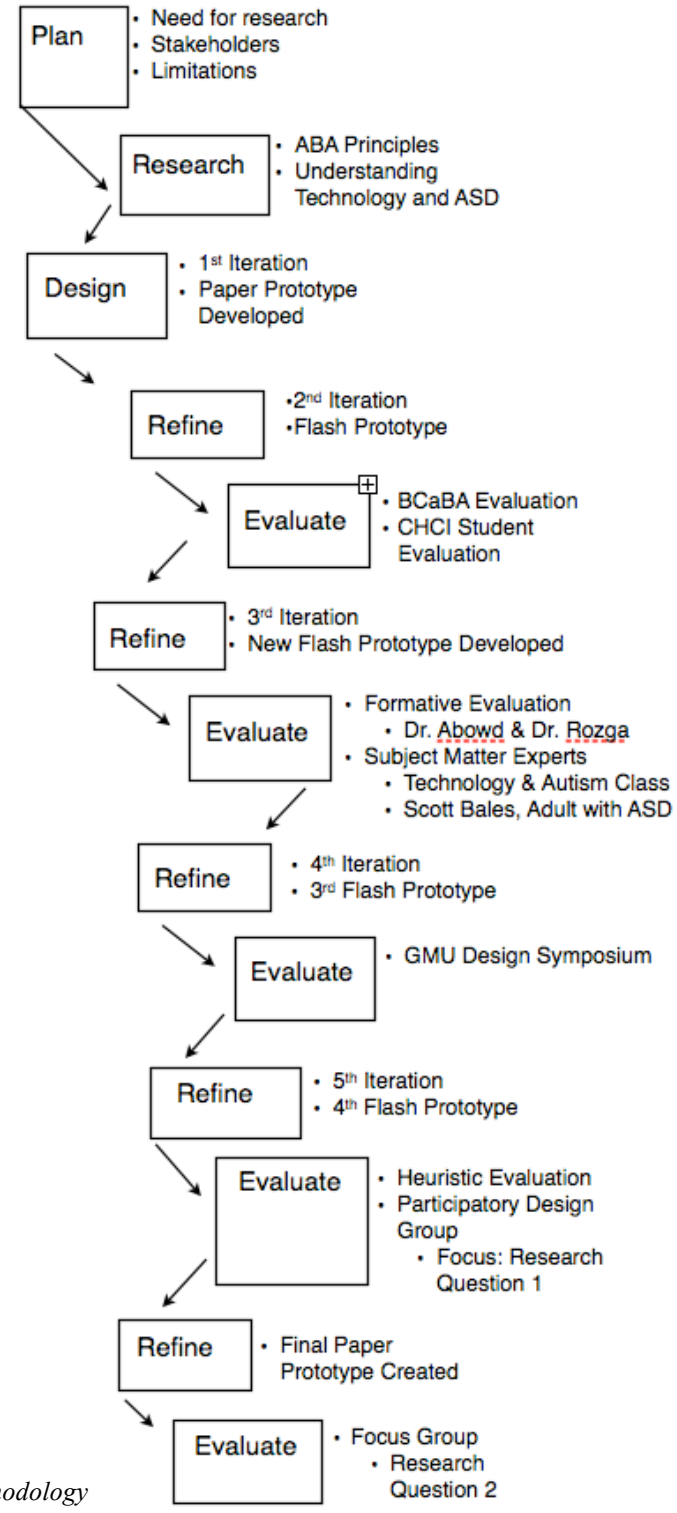


*Figure 10: Study Methodology*

## *5.1 Part One: Heuristic Evaluation*

Once the game prototype had been created with the advice and evaluation of several professionals in related arenas, the researchers selected to administer a heuristic evaluation of the prototype itself. Participants were asked to answer a set of questions based on each major design element (e.g. motivation through positive reinforcements, distraction points versus focal points, etc.) within the game. The ultimate goal of the heuristic evaluation was to select elements, which would be the targets of the subsequent participatory design group.

### *5.1.1 Participants*

Heuristic evaluation is a common tool in user-centered design; therefore, Nielsen and Molbich (1990) published standards on how to conduct this type of evaluation. It was determined that three to five evaluators would encounter up to two thirds of the problems within a system and 15 or more evaluators would encounter 75% or more of the problems. For this reason, the current aimed to recruit, at minimum, 15 evaluators. The response level was high and a total of 24 subject matter experts (SMEs) participated fully in the heuristic evaluation.

Participants were included in the study and considered qualified to complete the evaluation through their employment in the summer program, HI-STEP, located in Hopewell, New Jersey. HI-STEP is a program that was created by ABA specialist, Dr. Michael Selbst, for children with ASD and other social disorders between the ages of 5 and 16 years. SMEs for the current study completed the heuristic evaluation during the last 2 weeks of the program, thus they had had sufficient exposure to children with ASD, as well as relevant training. Participants were asked to list any relevant degrees or certifications to the study and the results included the following:

- Bachelor's Degree
    - Special/Elementary Education (3)
    - Psychology (7)
    - Biology (1)
- Master's Degree
    - Special/General Education (7)
    - Social Work (2)

    - School Counseling (2)
    - School Psychology (1)
- Certifications
    - Special/General Education (8)
    - School Psychology (1)
    - School Social Work (2)
    - Licensed Clinical Social Worker (LCSW) (1)
    - Licensed Social Workers (LSW) (1)

*5.1.2 Instruments*

This study utilized a researcher-developed questionnaire focusing on the different design elements of each screen display. The questions dealt with general design concerns (e.g. How many design elements were functional versus distracting?) ranging through to very specific questions relating to the use of the game by a person with ASD (e.g. How well does the fading mechanism guide you to the proper choice?). The questionnaire followed the sequence of the game format with the goal of uncovering which elements could remain in the design and which elements needed further consideration through the participatory design group, the second phase in the evaluation process. See A.2 for the full list of questions used during the heuristic evaluation.

Using Cronbach's alpha for a test of reliability in JMP 9, the questionnaire was found to be reliable. Matched questions measuring the motivation of the opening screen obtained a reliability score of .74. Questions measuring the likeness to other computer/video games in the level selection screen were found to be highly reliable (.92). Questions measuring the same concept within each of the three levels were also found to be reliable (Level 1: .88, Level 2: 88, and Level 3: .95). Questions measuring the clarity of instructions across the entire game process were found to highly reliable as well, with a score of .83. It is generally accepted that a Cronbach's alpha higher than .7 is considered "good" reliability, higher than .8, "high" reliability, and .9 and above, "very high" reliability.

*5.1.3 Procedure*

To protect the internal validity of the study, each participant experienced the same procedure when evaluating the game. After recruitment, a sign-up sheet was placed in

the staff room Stony Brook Elementary School, the location of HI-STEP. Each time slot was for the half hour following the typical day at HI-STEP (i.e. 8am-2:30pm with the children, then 2:30pm-3:30pm in a staff meeting; thus, the study took place from 3:30pm-4pm, approximately). Each time slot allowed for two participants to sign up, as the study was completed in pairs. This allowed the benefit of out loud thinking and "back and forth" idea generation between the two evaluators. All participants had signed up for a time to come in and complete the evaluation prior to the start of the evaluations.

On the day of each participant's evaluation, they were asked to stay after the daily staff meeting. Once everyone had cleared from the room, they were given the Informed Consent form to read over, see A.3. If they had any questions, they were directed to ask them at that time. If there were no questions, they were asked to sign the Informed Consent and turn it in to the researcher. Once the researcher received the informed consent form from both participants, the materials for the evaluation (i.e. the evaluation form and a pencil) were delegated. At this time, the researcher read a short description of how the study would proceed:

> *"Thank you for your participation in the current study. Remember that if at any time you feel uncomfortable or wish to end your participation for any reason, you may do so without consequence. First, please fill out the first five lines asking you for some demographic information. Leave the last line in this section, entitled 'Time Spent on Game Play," blank, as you will complete this at the end of the evaluation. Let me know when you have completed this information or if you have any questions."*

At this time, the researcher answered any questions and then waited for confirmation that both participants had completed this information. Once this occurred, the researcher continued with the description of the study:

> *"Now you will begin the evaluation of the game prototype. Each screen corresponds to a section of questions. Each section of questions is separated from the others with a title in all capitalized letters. Please complete all questions in that section before moving on to the next screen. Additionally, there is space in each*

*section for you to give open responses to clarify any of your responses. Please use this space as you see fit. You will have to communicate with each other to ensure that you have both completed the section, as I will be here to answer your questions, but I will not be participating in the evaluation with you. Do you both understand and feel ready to begin?"*

Once both participants agreed that they were ready to begin, the researcher allowed the participants to begin to the evaluation:

*"Okay, please double click on the icon labeled 'Final Game' and begin."*

When participants clicked the icon and began the evaluation, the researcher started a timer to track how long it took each set of evaluators to complete all three levels of the prototype evaluation. During the evaluation, the researcher observed and noted all technical issues and design flaws within the game itself. Because the session was held at a school and there was the possibility of children entering the room, the session was not able to be video or audio taped and pictures could not be taken.

Once the participants had completed the evaluation, the timer was stopped and the researcher instructed the participants to go back to the first page of their packet and record the number of minutes that were timed by the researcher. After the time had been recorded, the researcher collected the packets from each of the participants and began the compensation process. Each participant was given a check for $10 for participation in the study and asked to sign a receipt, stating that they received their compensation. Once all data had been collected, it was entered into JMP 9 software for analysis. Results for this portion of the study can be found in Section 6.1.

### *5.2 Part Two: Participatory Design Group*

Once the game prototype had been evaluated, as described in the previous section, and design elements were isolated, a participatory design group was formed to answer the first research question (see Chapter 4), developing design guidelines for ASD computer-based interventions. Past research has shown participatory design to be a successful tool

in designing for the target population (Wu, M., Baecker, R., & Richards, B., 2005; De Leo, G. & Leroy, G., 2008), alleviating some of the limitations and difficulties typically associated. The researcher utilized the collaborative prototyping method for design in which participants are asked to work together, discussing each element and adding input from their own experiences in their specific domain, coming to a finalized conclusion for each design element. The ultimate goal of the participatory design group was to develop finalized design guidelines addressing issues that were underlined in the heuristic evaluation.

*5.2.1 Participants*

Following standards developed by Muller and Kuhn (1993), it was determined that this group, utilizing a "collaborative prototyping for design" method, would require what the researchers referred to as either a TINY or a SMALL group of participants. TINY required 2-4 participants, while SMALL required 6-8 participants, giving the current study a recruitment goal of about 5 participants. Five areas of expertise were recruited for and considered as a stakeholder in this form of ASD intervention:

- Autism, ABA
- Education
- Gaming
- Human-centered design
- Instructional Design

Note: there were no repeat SMEs used in the participatory design group (i.e. no one from the heuristic evaluation was used in this group). Recruitment took place through Listserv emails at Virginia Tech within each of the departmental areas of expertise. Following the work of De Leo, G. and Leroy, G. (2008), it was determined that proxies to the actual target population would be needed. In their study, the researchers employed special education teachers in the participatory design group. Because of the more complex and novel approach of the current study, it was necessary to go beyond education experts.

*5.2.2 Materials*

No formal instruments were used in this portion of the study; however, there were several materials that were vital to the successful outcome of the participatory design group. Each participant was given a pencil and scrap paper to jot down ideas during the

session. This helped to alleviate forgetting if participants were waiting for others to finish expressing their ideas. Also, there were extra design materials (e.g. markers, colored pencils, different colors of paper, etc.) for all participants to share if needed to better illustrate their ideas. The researcher utilized her computer for a demonstration of the Macromedia Flash ® prototype, the use of auditory clips, as well as to voice record the session.

*5.2.3 Procedure*

Once all five participants had agreed to the terms of the study, a Doodle ® poll was created to find a common time to hold the participatory design session, as students at Virginia Tech are generally familiar with this method of scheduling. The session was scheduled approximately 3 weeks ahead of time; thus reminders were sent at 2 weeks, 1 week, and 1 day prior to the session; in an effort to ensure that all participants would be able to attend during the scheduled time. Since each person represented a vital stakeholder to the study's interest, it was essential that all were present on the day of the group.

On the day of the session, all participants and the researcher met in private room. Each participant was given a pencil and scrap paper and asked to wait for further instructions. In the center of the table were some extra design materials (e.g. markers, colored pencils, different colors of paper, etc.) for sharing purposes. The researcher had large screenshot printouts of each scene that could possibly be encountered during a session with the game prototype. Once all five participants had arrived, the researcher began the voice-recorder, introducing herself informally and asking that all participants do the same, such that everyone could become acquainted and more comfortable with each other. The session was voice-recorded as a secondary means of capturing insight; however, at the conclusion of the session, final design guidelines, presented in the results section, were agreed upon.

After introductions, the researcher distributed the Informed Consent form (see A.4). Participants were given sufficient time for questions. After all questions were answered, they were asked to sign and return the Informed Consent form. Next, the researcher summarized how the participatory design session would proceed:

*"Thank you all for joining me today. As you read in the recruitment email, we are going to be doing a walk-through of a game prototype that I have developed to augment certain social skills in children with autism. The prototype will be using gaze following, a correlate of joint attention, as the social skill to be taught. I am going to begin with a description of the target user group, mostly for those of you who aren't directly familiar with children who have ASD. Then I will show you a demonstration on my computer of the Flash® prototype, as we will be working from the paper screenshots for the actual design session. This will give you a more holistic idea of the prototype. I will then discuss the key elements that were identified during a previous evaluation of the prototype. This has provided the structure for this design session and I feel it is important to know why each point was selected. Finally, I'm going to explain the aim of the final design and the three main points to be analyzed. Then, we will begin. Everything will be timed to ensure that we stay on target; however, since you have all said you are free for the hour following the study, feel free to ask for extra time if necessary for certain elements. Does anyone have any questions before we begin?"*

After the summary was read aloud to the participants and all questions had been answered, the researcher gave a short description on the target user group, 4-6 year old children with ASD, and allowed for any questions that the participants might have about designing for children with this disorder. Next, there was a demonstration of the current Macromedia Flash® prototype. This allowed the group to see the game in its entirety, before breaking it down by individual design elements. Next, a summary the results of the heuristic evaluation, see Section 6.1, was given, followed by a discussion of the overall aim of the final design. Because of time constraints, the participatory design group was scheduled and timed using complexity of design element (e.g. less complex elements were allotted smaller time blocks) as follows:

- Motivation to play (Intrinsic motivation) (3 minutes)

- Positive reinforcement (2 minutes)
    - Verbal
    - Non-verbal
- Level Change (1 minute)
    - Difficulty
        - Frustration vs. Challenge

- Salience of learning points (2 minutes)
    - Distraction points versus focus points (1 minute)
        - A numbered ratio (For example: 3:2, 1:2)
    - Clarity and appropriateness of instructions (1 minute)
        - Verbal vs. written vs. both
        - Length, wordage used
- Likeness to other computer and video games (5 minutes)
    - Short description of popular video games for age group
        - What makes them fun
        - What makes them challenging

After all necessary background information had been disseminated; the participatory design session began. The storyboard was presented as a guided collaboration of each point. There was a total of 95 minutes allotted to the session, and extra time was not needed (see A.5 for a full schedule of elements). For each scene that had a concurrent auditory instruction or feedback, the sound clip was played from the researcher's computer at the appropriate time (e.g. as if the participant had clicked on an icon, selected the right/wrong answer, etc.). When there was dissent among the participants, it was the role of the researcher, acting as a facilitator, to ensure all opinions were being heard and considered. When time limits were reached, the researcher gave reminders and pushed for a final decision. With a limited number of elements, dissent was unmoving, and design choices were voted upon, with majority selection. This is a limitation of the method of collaborative prototyping participatory design. Future researchers should consider having each participant rate how much they agree with each element in private after it is selected; therefore getting a better understanding of

individualized opinions and looking to see if "groupthink" played a part in the decision-making.

After all design elements were agreed upon and finalized by the group, participants were dismissed from the study. There was no compensation provided for participation in this part of the study. Results from this portion of the study, namely the finalized design guidelines, can be found in Section 6.2.

## *5.3 Part Three: ABA Appropriation Evaluation*

The third and final stage of this study was to present the game in front of persons (i.e. parents and education professionals) familiar with ABA and other autism interventions. The ultimate goal of the ABA evaluation was to evaluate the game in terms of the second research question: To what extent does this game format appropriately recreate the ABA guidelines and practices used in the intervention of children with ASD, specifically in terms of gaze-following behavior augmentation, a subset of RJA training? Overall, this was achieved through written questionnaires containing both open- and close-ended questions following a one-hour presentation of the overall research focus.

### *5.3.1 Participants*

To obtain participants for the ABA Appropriation Evaluation, the local Special Services School District of Mercer County (MCSSSD) was contacted. The head of the parent teacher association (PTA) in the district, invited the researcher to present the study, as well as to collect data from teachers and parents at the Parent Advisory Counsel (PAC) meeting, their monthly group meeting. Participants were not compensated monetarily for filling out the questionnaire; however, by attending the meeting and participating in the presentation, they were able to gain a two-hour credit towards their yearly requirements as members of PAC.

Recruitment and participation is a known difficulty for studies when using special and hard-to-reach populations. Similar studies (Whalen, Liden, Ingersoll, Dallaire, & Liden, 2006; DeLeo & Leroy, 2008; Wu, Baecker, & Richards, 2005) were able to successfully test their hypotheses with as few as 10 participants. Because the studies had similar evaluation techniques and utilized teachers and educations professionals in the same way as the current research, the recruitment goal for this part of the study was set at

10 participants. The study was able to recruit and obtain data from a total of 13 participants. Note: there were no repeat SMEs used in the ABA appropriation evaluation (i.e. no one from the heuristic evaluation or the participatory design group was used during this evaluation).

Participants included five special education teachers in the MCSSSD, one computer specialist for children with ASD in the MCSSSD, two special education teaching assistants, one para-professional, one social worker, one Board Certified Behavior Analyst (BCBA) and parent of a child with ASD, and two parents. Experience with ASD and ABA ranged from nine to 28 years.

*5.3.2 Instruments*

This stage of the research utilized a researcher-developed questionnaire, which aimed to obtain insight from participants about this innovative type of intervention. Questions were formulated under the guidance of a professional in ABA with the intent of measuring how successful the game was in mirroring traditional face-to-face interventions for young children with ASD. Questions were built on a 10-point Likert-type rating scale, as well as open-ended format. See A.6 for the full list of questions used during the heuristic evaluation. Following the general "rules" for Cronbach's alpha stated above, matched questions were found to have very high reliability (.96).

*5.3.3 Procedure*

After contacting MCSSSD, a PAC meeting was scheduled during which this portion of the current study could take place. Upon arrival to the PAC meeting, the researcher gave an informal description of how the session was going to proceed. It was explained that a one-hour presentation on the study would be given, including a demonstration of the game prototype and results from the previous two stages of the research, and concluded with a questionnaire, asking them to share their views and opinions.

During the one-hour presentation, the researcher introduced herself and the work. Included in the presentation was the following: 1) motivation for the current work, 2) background on ASD and ABA, 3) a short literature presentation on computers games, ASD, joint attention, and user-centered design, 4) a demonstration of the Macromedia Flash ® prototype, 5) results of the first two stages, including the finalized guidelines

developed by the participatory design group, and 6) the long-term goals of the study. Participants were permitted to interrupt the presentation at any time to ask questions, as this opened up the floor for discussion on the game-like intervention. After the presentation was complete, a final round of questions/comments commenced.

At the conclusion of the presentations, those who had committed to participating in the questionnaire research were asked to remain, while others were dismissed from the presentation. The informed consent form (see A.7) was distributed to each of the 12 participants. Participants were given sufficient time to read over the form and to ask any questions that they might have about it. Once all questions were answered, the participants were instructed to sign and date the form. The forms were collected and the questionnaires were distributed. Participants were told that once they completed the questionnaire, they could return it to the research and exit the study. There were no questions presented to the research as the questionnaires were being completed.

Once all questionnaires had been return to the researcher, the study was considered closed for that time. Some participants remained after the close of the study to discuss the reality of using a game, such as the one presented, in their classroom as alternative ASD interventions. A few education professionals were interested in potentially having the game, and although the prototype is not yet launched for use on children, it showed the interest and need for new avenues of ASD intervention.

# CHAPTER 6. RESULTS

The results of this study are presented below by each stage of research. Note that because of the novel and exploratory approach to this study, all of the results are descriptive. It is the hope of the researchers that these exploratory results will help to lay the grounded work for more empirical studies of this nature.

## *6.1 Part One: Heuristic Evaluation*

The heuristic evaluation items were based on a 10-point Likert-type rating scale. It was determined prior to the study that a score of eight or above would NOT qualify for evaluation in the participatory design group, whereas a score lower than 8 would. Because the study was extracting feedback from teachers and others in the education profession, a high set point was selected because of the critical nature. Additionally, as a post-hoc measure, it was determined that eight was the approximate mean of all scores, further supporting its selection as the cut-off point.

The main goal of the heuristic evaluation was to determine which design elements needed focus in the second stage of the study, the participatory design group. This portion of the study was mainly exploratory in nature, attempting to uncover the design flaws within the game prototype.

JMP 9 software was utilized for analysis of the data. Below, the results are presented, highlighting which elements were selected for the participatory group, and those which were determined sufficient to maintain within the current design.

### *6.1.1 Descriptive Statistics*

Within the Opening Screen, it was found that the clarity of instructions to select a character met the study's criteria ($M$ = 8.54, $SD$ = 1.61) and remained in the study's design. However, the enticement or motivation to play the game, including the character variety, was comparatively low ($M$ = 7.38, $SD$ = 1.84; $M$ = 7.21, $SD$ = 1.35, respectively).

Within the Level Selection Screen, it was found that the clarity of instructions to select a level and the enticement to select a level and continue the game scored high enough to remain "as is" within the game design ($M$ = *8.75*, $SD$ = 1.48; $M$ = 8.43, $SD$ = 1.27, respectively). However, the current game prototype and other video/computer games were found to have not many similarities ($M$ = 7.92, $SD$ = 1.69; $M$ = 7.79, $SD$ =

1.59, respectively). Having a high level of similarity to other computer and video games was an important goal of the current study; therefore, these elements were also selected as focal points for the participatory design group.

In all three levels, it was found that the likeness to other computer and video games was unsatisfactory (Level 1: $M = 6.83$, $SD = 1.86$; $M = 6.33$, $SD = 1.90$, respectively; Level 2: $M = 7.33$, $SD = 1.61$; $M = 6.71$, $SD = 1.57$, respectively; Level 3: $M = 7.04$, $SD = 2.07$; $M = 6.67$, $SD = 2.24$, respectively). Because this element was an issue through all three levels, as well as the Level Selection Screen, it was selected as a design element and an overall goal for the participatory design group. Similarly, in all three levels the instructions were found to be unclear (Level 1: $M = 6.65$, $SD = 2.34$; Level 2: $M = 7.67$, $SD = 1.95$; Level 3: $M = 7.79$, $SD = 2.17$) and needed an overall redesign.

In regards to the motivation to continue playing the game, it was found that Levels 1 and 2 ($M = 7.50$, $SD = 1.89$; $M = 7.79$, $SD = 1.35$, respectively) were not intrinsically motivating. Additionally, some interesting comments came from the open-ended sections of the evaluation. Participants acknowledged that the game was fun to play; however, needing 30 points to move on was "too many" and would induce a sense of "boredom in many kids". Some direct quotes include: "it may be hard to keep attention for 30 responses" and "30 points to reach might become somewhat boring for the kids to be doing the same thing." Because the number of trials could not be reduced based on previous literature described in Section 3.3, the participatory design group was charged with the task of making the game intrinsically motivating and "fun" for a longer period of time.

All results from the fading portion of the questionnaire were disregarded as a result of the high level of confusion among most participants. Verbal comments and questions were recorded and the researcher found that most participants thought the fading prompt was showing what the correct answer *should have been* not *what it was* at the time. For example: if they got a question wrong, they thought the prompt was showing what the right answer had been for the previous round, not prompting them towards the correct answer for the current round. Other participants were unaware of the fading mechanism altogether. Additionally, the open-ended comments reflected

confusion and misunderstanding as well. Direct quotes from the participants include: "flashes are confusing," "seemed like fading was a step behind," "the fading was not very clear," "I wasn't aware of the black fading and when the examiner showed the black fading it seemed as if it was a step behind," and "I did not even notice the fading directing to the correct answer. 2nd time around noticed, not sure if kids would pick up on this." As a result of this confusion, the fading mechanism was given a large portion of discussion time within the participatory design group, making it eligible for a complete redesign.

The use of points was considered useful in terms of positively reinforcing children to engage in gaze following behaviors ($M$ = 8.46, $SD$ = 1.18; $M$ = 8.29, $SD$ = 1.80, respectively). It was decided that the point system would be maintained; however, because the perceived saliency of the scoreboard dropped in each level (Level 1: $M$ = 8.13, $SD$ = 1.54; Level 2: $M$ = 8.00, $SD$ = 1.56; Level 3: $M$ = 7.42, $SD$ = 1.77), it was determined that the presentation of the points needed to be redesign in such a way that achieved continued saliency.

The Level Change Reward Screen scored high in terms of reinforcement and rewarding qualities ($M$ = 9.13, $SD$ = 0.85). Additionally, the videos were found to be an appropriate means of rewarding the player for successfully completing each level ($M$ = 8.95, $SD$ = 1.00). Because of the high scores for this game element, a redesign was not be included in the participatory design group; however, the screen itself was included in the storyboard for entirety.

Data was non-normally distributed; however, because standard deviations were small (all < 2), this was not considered to be a concern.

### *6.1.2 Selected Design Elements*

Below is a summary that highlights which elements, based on the above results, were selected as focal points for the second stage in the research process, the participatory design group.

- Overall
    - Motivation to Play
        - Positive Reinforcement
            - Verbal

                - Non-verbal
        - Salience of Learning Points
            - Distraction Points versus Focal Points
            - Clarity and Appropriateness of Instructions
                - Verbal versus Written versus Both
                - Length, Wordage Used
        - Likeness to Other Computer and Video Games
            - Fun AND Challenging
            - Intrinsically Motivating
- Clarity and Presentation of Instructions/Corrections
    - Address in All 3 Levels
- Fading
    - Complete Redesign
        - Less Distracting
        - More Informative, Clear
    - Address in All 3 Levels
- Presentation of Points
    - Address in All 3 Levels

## *6.2 Part Two: Participatory Design Group*

Following the successful outcomes of a similar participatory design group by De Leo and Leroy (2008); the current research intended the session to develop and agreed upon general design guidelines, those of which could be applied to the current game based on the design issues/concerns uncovered in the heuristic evaluation, as well as to other, future social skills video and computer games. Through discussion on each element, this goal was achieved and in the following section (6.2.1) the guidelines are delivered.

### *6.2.1 General Design Guidelines*

Following a similar descriptive approach (Massimi, M., 2007), the general design guidelines that were developed and agreed upon within the participatory design session are listed below, followed by a figure illustrating where each guideline fits into one (or more) of the three main design goals as stated in Section 5.2.3:

- Opening Screen
    - **Stating a purpose/goal:** At the beginning of the game, there should be a goal set forth for the game player. The goal should fit with the theme of the game. For example: If the game is a safari, the goal might be to fill the animal's food dish so that they can eat during feeding time.
    - **Use the word, "friend."** When inviting the child to play, the figure within the game should be called a friend, as opposed to a helper. This empowers the child and puts them at the forefront of the game.
    - **Name the character.** Each character available for selection should have a different name.
        - **Allow the character to interact.** The character should state this name when the child places the cursor in the mouse over area of the character.
- Focus Points
    - **Enlarge focus points.** The location in which the player should be looking should be exaggerated. For example: In this game, the eyes are the focal point and therefore, should be enlarged.
        - Also within this specific design, the face of the character itself should be larger than all other objects, giving the player a *main* focal point.
    - **Fade background.** The background should have few objects within it. Also, the color of the background should be faded to a lower saturation than the necessary game elements.
    - **Mouse over change.** Clickable items should highlight or become slightly larger when the player reaches the mouse over area, while un-clickable objects should be faded.
- Grading
    - **Point meter.** The game score should be shown as a point meter, reflecting overall progress towards the specified goal. For example: If the goal was to fill the animal's food dish, the point meter should be a food dish showing how much more food is needed to fill it.

- **Points should never be subtracted.** When a child gets an answer wrong, they should not lose any of the previously earned points.
- **Wrong answers ignored.** Nothing should happen when a wrong choice is selected. After 3 wrong attempts, the character should remind the player to "look at my eyes;" however, it should not state that a wrong answer has been selected.

- Auditory Instructions/Feedback
  - **Voice should match picture.** The character's voice should not be distorted at all. If the picture selected is an adult male, the voice should be of an adult male. If the picture selected is a child female, the voice should be of a child female, and so on.
  - **Shorten all verbal clips.** All game feedback and instructions should be as verbally short and concise as possible.
  - **Positive reinforcement should vary.** The clips stating that the child has selected the right choice, etc. should vary (including the length of the clip, as well as the chosen vocabulary).
- Fading
  - **Arrow to correct answer.** Fading should include an arrow from the eye of the character moving down to the correct answer selection, guiding the player to the target.
  - **Arrow should fade.** The arrow used should become less and less salient as the child selects correctly.
  - **Fading in 1st and 2nd levels only.** The fading should be included in all but the final level of game play.
- Game Overall
  - **One narrator throughout entire game.** The narrator should serve as an omniscient character and remain the same, also matching the theme of the game. For example: If the game is a safari, the narrator could be a giraffe and should be the same giraffe throughout all screens.
  - **Level consistency.** The game should follow a story format, keeping the same theme from level to level.

- **Music on/off option.** Because some children will find the background music distracting, while others will find it amusing, there should always be an option for the child to leave the music on or to turn it off.
- **Selection consistency.** All choices for the game player to make (e.g. character selection, level selection, etc.) should be on the same side of the screen.
- **Undo option.** On each screen, there should be a back arrow, indicating the option to go back one step.
- **Automatic save.** The game should automatically save the player's progress, such that if accidently logged out, the player does not lose their spot.

Please see the following page for a summary chart of all selected design elements. NOTE: The participatory design group was charged with the goal of making the design elements with the idea of generalization to other social skills interventions in mind; however, to measure this, it would be necessary for future research to understand the ABA guidelines for different social skills and evaluate the guidelines in that sense. It was not within the current researcher's scope to do so.

| | | Design Intent | | |
|---|---|---|---|---|
| **Design Element** | **Purpose** | **Motivation to Play** | **Salience of Learning Points** | **Likeness to Other Computer/Video Games** |
| **Stating a purpose/goal** | Gives the child a reason to play | √ | | √ |
| **Use the word, "friend," for characters** | Empowers the child | √ | | |
| **Name the characters** | Personalization | √ | | |
| **Allow the character to interact** | Personalization | √ | | √ |
| **Enlarge focus points** | Guide child to where he/she should look | | √ | |
| **Fade Background** | Avoids distraction | | √ | |
| **Mouse over change** | Highlight clickable items as a "clue" of where to click | | √ | |
| **Point meter** | Show child how close he/she is to his/her goal | √ | | √ |
| **Points should never be subtracted** | Keeps the game positive and rewarding | √ | | |
| **Wrong answers ignored** | Keeps the game positive and rewarding | | √ | |
| **Voice should match picture** | Avoids confusion of mismatch for the child | | √ | |
| **Shorten all verbal clips** | Short/concise instructions to reduce confusion | √ | √ | |
| **Positive reinforcement should vary** | Increase variety | √ | | |
| **Arrow to correct answer** | Guides child to the target | | √ | |
| **Arrow should fade** | Increase reliance on child for correct responses | | √ | |
| **Fading in 1st and 2nd levels only** | Fading removed when skill is increased | | √ | |
| **One narrator throughout entire game** | Continues the idea of having a "theme" throughout the game | √ | | √ |
| **Level consistency** | Continues the story to increase motivation | √ | | |
| **Music on/off option** | Increase variance: some enjoy the music, some find it distracting | | √ | √ |
| **Selection consistency** | Options on same screen side | | √ | |
| **Undo option** | Avoid some frustration | √ | | √ |
| **Automatic save** | Avoid losing progress | | | √ |

*Table 1: Design Guidelines*

It is important to note that the design guidelines were developed as an inclusive design for young children with ASD. For this reason, 100% of the guidelines must be utilized. All guidelines were selected in an attempt to accommodate the behavioral excesses and deficits, including rigidity and routine, found in children with ASD. Additionally, because of the variance among child on the spectrum (e.g. one child might need the option to undo, while for another it is more important to have a goal in mind), an inclusive design attempts to accommodate as many children as possible, accounting for a variety of deficits and excesses, as well as the routine nature of the children.

It is also important to look at the alignment between the general guidelines developed by the participatory design group (see page 80) and the universal design guidelines (The Center for Universal Design, 1997). The first principle calls for equitable use, or the avoidance of stigmatization of any users. Because the design framework calls for different levels of difficulty, it is able to accommodate different levels of functioning, therefore, attempting to make the design appealing to and usable by many users. The second principle calls for flexible use, or the ability for choice and adaptability within design. The design framework offers a variety of characters, lending itself towards the idea of flexibility. Additionally, one of the guidelines calls for the ability to turn the music on and off. Some children might be amused by the music, while others become distracted. Having the option to turn it on and off allows for flexibility within the design.

The third principle of universal design calls for simple and intuitive use through the avoidance of unnecessary complexity and consistency with user expectations. The first design guideline that aligns with this principle is the use of short and concise verbal instructions. This helps the user to concentrate on the instructions being given, as well as simplify the information being presented. Additionally, having the "clickable" items change when the child enter the "mouse over" area simplifies use by showing the user which items are able to be selected and ignoring those which are not. The fourth principle calls for perceptible information by means of the use of multiple modalities, as well as ensuring that pertinent information stands out against the background. First, the design guidelines developed by this study call for both verbal and visual direction. Second, the guidelines express the need for the background to be subdued, while the

focus points are enlarged, making it more obvious to the child where he/she should be looking. Finally, the principles of universal design call for a tolerance for error. This was achieved in two parts by the developed design guidelines: 1) the option to "undo," and 2) automatic save. Although this principle of universal design is intended to avoid physical and large-scale hazards, it applies in a much simpler way here. If a child has the option to undo, small errors will not distract him/her from the ultimate goal of the game. Also, by automatically saving, the game helps to avoid frustration of losing progress, if he/she should get accidently signed out.

## *6.3 Part Three: ABA Appropriation Evaluation*

The goal of the ABA evaluation stage of this research was mainly to begin exploring research question 2: To what extent does this game format appropriately recreate the ABA guidelines and practices used in the intervention of children with ASD, specifically in terms of gaze-following behavior augmentation, a subset of RJA training?

### *6.3.1 Close Ended-Questions*

As shown in A.5, there were 5 close-ended questions on the ABA questionnaire. Scoring was based on a scale of 10, and again, a score of 8 was selected as the set point for what was to be considered a "success." Again, a high set point was necessary being that feedback was obtained from teachers and education professionals, a critical population. The first question asked participants to rate the appropriateness of video games to teach children with ASD. A score of 1 meant that the participant thought video games were an inappropriate means of teaching children with ASD, while a score of 10 meant that the participant thought it was an appropriate means of teaching children with ASD. It was found that the participants in this study found the use of video games to be an appropriate intervention for this population ($M$ = 8.69, $SD$ = 1.11). The second question asked participants to rate the appropriateness of computer games to teach children with ASD. The scoring technique mirrored the scoring technique of the first question. Again, participants found this type of intervention to be appropriate for children with ASD ($M$ = 8.92, $SD$ = 1.12). The results of the first two questions demonstrate great hope for this line of cheaper and easier ASD intervention and support the current research's goal of beginning the design framework for this line of intervention methods.

The third question asked participants to rate the game prototype's current ability to encompass traditional ABA practices, as all participants had experience with this form of ASD intervention. It was determined by participants that the game was able to encompass traditional ABA practices (*M* = 7.85*, SD* = 1.82*)*; however, because the score did not reach 8, the selected criterion, the researcher believes there is room for improvement, thus further iterations of the game will need to be made in a future study. Similarly, the fourth question asked participants to rate the current game's ability to teach social skills in general to this population. Again, the score did not meet the "8" criterion and therefore, will be in need of further evaluation (*M* = 7.38*, SD* = 1.93*)*.

The final item asked participants to rate the current game's ability to teach the specific social skill presented, gaze following, to children with ASD. Because this correlate to joint attention is relatively new within ASD research, it was determined prior to the start of the session that all participants may not be experienced with gaze following techniques. Therefore, participants were given written instruction to leave that item unanswered if they were unfamiliar with gaze following. Twelve of the 13 participants responded to the question, only one abstained due to a lack of experience. Participants rated the game as "able" to teach gaze following behaviors to this population (*M* = 8.58*, SD* = 1.16*)*.

Data was non-normally distributed; however, because standard deviations were small (all < 2), this was not considered to be a concern.

It is interesting to note that the first two items, asking participants to rate the general ability of computer and video games to instruct children with ASD, were determined to receive successful results. Also, the final question, asking participants to rate the current game's ability to teach the specific skill of gaze following was determined to receive successful results. The only questions leaving the researcher with further evaluation desired were the two items asking general questions about the current specific game prototype (i.e. it's ability to encompass ABA practices and it's ability to teach social skills). It might be possible that the participants were unable to look at a specific example and rate it in a general manner. Therefore, the lower scores may have been a questionnaire design flaw or participant misunderstanding, not necessarily flaws

of the game itself. Further investigation is necessary to determine this; however, it is of consideration.

*6.3.2 Open Ended-Questions*

The open ended-questions were included as a means to support the previous results. The results of these questions are presented with relevant responses delivered under the heading of each question:

*1) What do you think of the current game's ability to use traditional ABA practices?*

Responses to this question reflected a high level of positive comments. Out of 11 responses, 11 were found to be positive and 0 were found to be negative. Three themes were created out of the 11 positive responses including the game being "conducive to learning," a "great use of ABA," and a "good idea." Please view Figure 11 below for a complete count of responses:

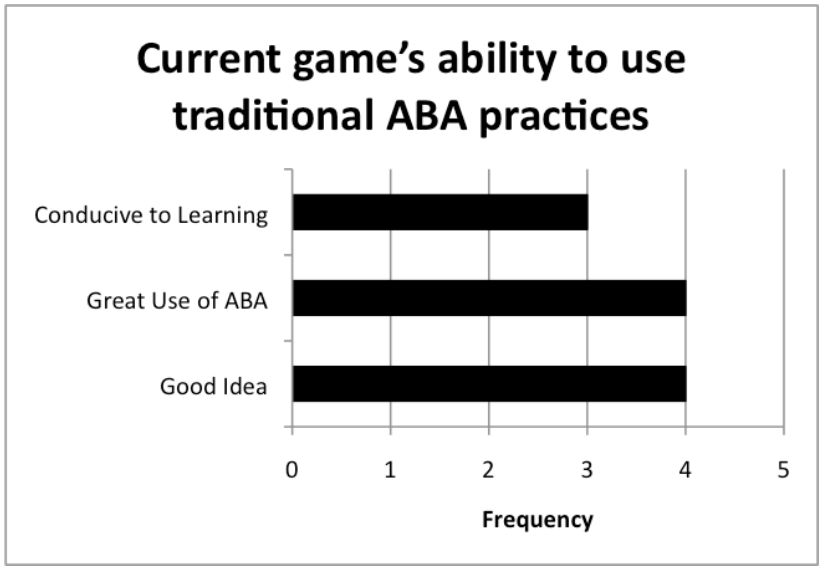


*Figure 11: ABA Q1*

*2) How well do you think the ABA practices were translated into game format?*

Responses to this question reflected comments that were 80% positive and 20% suggestive, in terms of elements that were thought to be in need of change. The two total suggestions (a frequency of one for each) included: a need for more breaks within each level (i.e. a break after 10 correct responses) and a need for more variety (i.e. expanding on the variation in each level and in the reinforcement used). From the eight positive comments, three themes were developed including the idea that "children with ASD

would response well," "ABA aspects were included," and that the practices "translated well." Please view Figure 12 below for a complete count of responses:

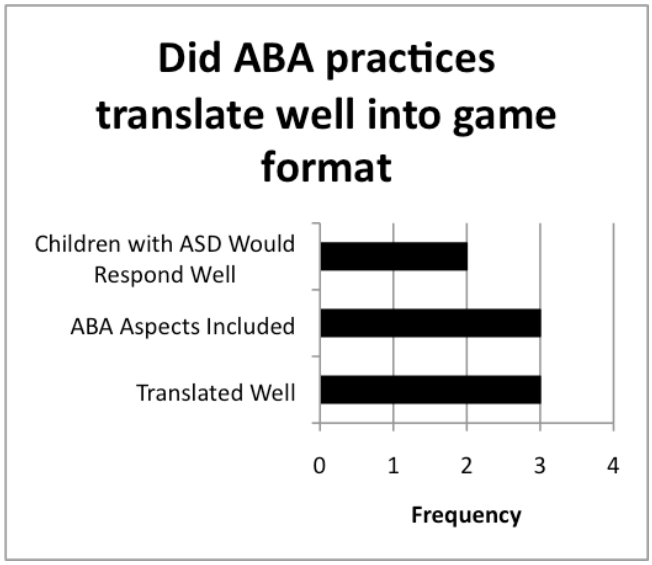


*Figure 12: ABA Q2*

*3) Please comment on the appropriateness of a video/computer game in ASD intervention.*

The response rate for this questions was low; however, it was determined that out of six comments, four were positive and two were concerns. The concern was for generalization of the game (i.e. transfer of skill to the natural environment). The positive comments feel under two themes: "very appropriate" and "highly motivating." Please see Figure 13 below for a complete count of responses:

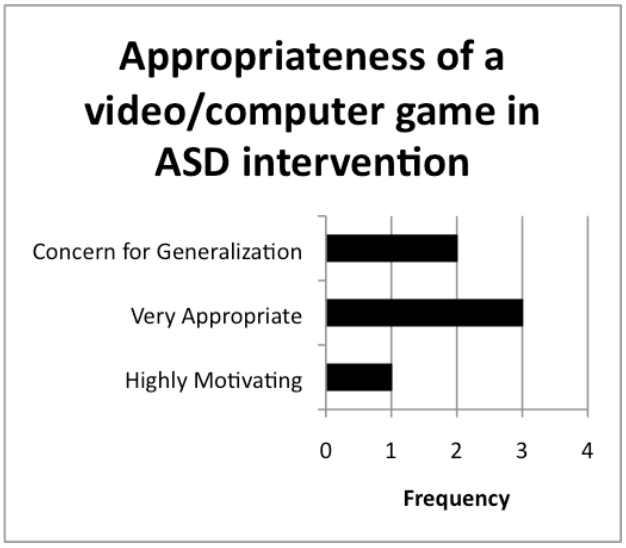


*Figure 13: ABA Q3*

*4) Please comment on the ability of a video/computer game to augment social skills.*

Out of six total comments, 83% represented positive responses, including "great potential" for this type of intervention in the augmentation of social skills. One additional comment was a concern, again for the ability of the game to accommodate the transfer of skill to the natural environment (i.e. generalization). Please see Figure 14 below:

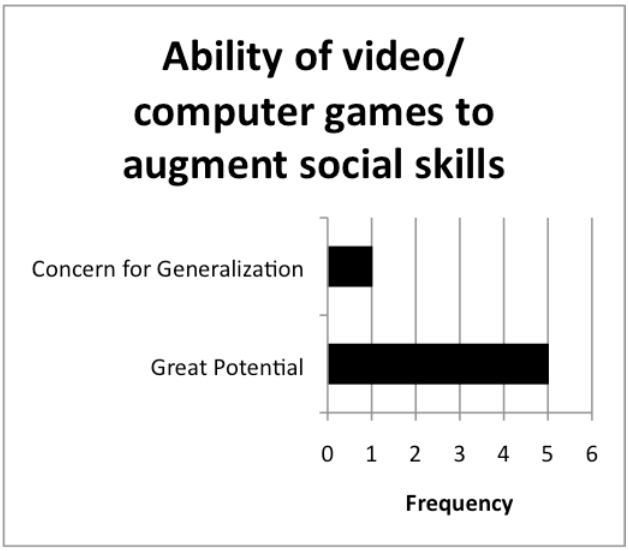


*Figure 14: ABA Q4*

*5) Would you choose to use this type of intervention?*

Out of ten total responses, ten participants said, "yes," they would use this type of intervention for young children with ASD. This reflects 100% of total respondents.

The open-ended questions, along with the results of the close-ended portion, support the current line of ASD intervention being suggested and developed by the current research. A need to further explore the game with children as participants has been expressed in the concerns for generalization, something that can only be evaluated through further studies. Overall, there is a place for this type of intervention with the ASD community, along with a need for further exploration to truly harness the potential benefits of an intervention of this form.

# CHAPTER 7. DISCUSSION

As shown previously, the earlier and more intensive behavioral intervention is for a child with ASD, the more effective it will be. Therefore, the goal of this research was to develop an intervention that was cost effective, as well as fun and independence establishing. Video and computer games are widely used by this population, making a computer game the subject of the study. Specifically, this research explored the development of a set of general design guidelines for use in the development of computer and video games as interventions in the treatment of Autism Spectrum Disorder (ASD), as well as a design framework for a computer-based game that appropriately encompasses the validated ABA principles used in traditional face-to-face therapies for the augmentation of gaze following behaviors, a correlate of responding to joint attention.

Because of the limited resources and literature available, the current study was largely exploratory. Beginning with an informal guided design process including a literature review and guidance from professionals and students in the field, a grounded prototype was developed. The heuristic evaluation including a step-by-step walk-through of the game revealed many design flaws to be addressed through the participatory design group. Through the participatory design group, a set of design guidelines were developed and later presented along with the game prototype to a group of individuals with experience in ASD intervention and ABA practices, gaining insight in the translatability of ABA standards into computer and video game protocols.

Additionally, because of the sensitive nature of the study population, it was necessary to employ future stakeholders within the heuristic evaluation and the participatory design group, as opposed to potential users, as the researchers would have preferred. This actually proved to present a more encompassing view of the work, being that virtually all fields were represented within the final design. The study's contributions are general design guidelines, which can be used in the developed of other social skills game aimed at ASD intervention, as well as a paper prototype encompassing the design framework. Subsequently, the study developed a reliable questionnaire (A.2), as well as a summary table for the communities of practice in this field, further described in Section 7.1.2 (Table 2).

### *7.1 Future Work*

As previously stated, this study was largely exploratory; therefore the current research has laid the groundwork for expansive future work, inclusive of controlled studies for future researchers interested in autism and technology. The next step in the continuation of this research would be to have either a second participatory design group, or a second evaluation, with participants who were on the spectrum. This could give new insight into what users want, as well as the possible difficulties someone with ASD might face in utilizing this tool as an intervention. It will then be necessary to evaluate the game experimentally with the target group (Section 3.4.5). Giving the experimental group the current game and a status quo game as a control group, it would be possible to utilize eye-tracking technology to objectively measure if gaze following behaviors increase with the use of the experimental game.

Once more objective measures are utilized to evaluate and potentially support the current line of intervention, it might be possible to use the design guidelines and design framework to expand this type of technology. The expansion could come in many forms. First, the current game is aimed for a young population. Therefore, it would be possible to reevaluate the design, attempting to make it appealing to and encompassing of older children and adolescents with ASD. In addition to encompassing larger age ranges, additional social skills should be considered for this type of intervention. For example, children could participate in "what should you do" situations, a common practice in ASD intervention. Being prepared for social situations is often times important in the use of appropriate social skills for this population; therefore, if technology could be used to help increase the level of practice, children and adolescents with ASD might become more comfortable and eventually more advanced in their use of everyday social skills.

It is also possible to expand on modalities used within the video games. For example, the games could eventually be played on devices like the Nintendo Wii ®. This could allow participants to engage in the physical aspects of social situations, such as waving or answering the telephone, common skills practices in ABA training. Currently, some researchers suggest that the innovative way in which players interact with the Nintendo Wii® may be beneficial to students with disabilities (Pearson, E. & Bailey, C., 2007). This underlines the potential for expansive benefit that technology could offer to

ASD intervention. Eventually, the intervention could encompass cognitive, social, and physical benefits. Future researchers should consider these benefits and the innovative technologies available for development in the intervention of this population.

## *7.2 Lessons Learned*

With every study and all research, there are times when the dead end roads taken have taught the researcher more than the easy roads. This is why although the deliverables in this research were the general design guidelines for the translation of ABA interventions into game and computer format, the researchers of this study have found it important to devote a section to the lessons that have been learned throughout the development of this current research and advice to future researchers embarking on similar studies.

### *7.2.1 Planning Ahead*

The original scope of this research was so expansive that it would have taken not only many years to complete, but also a lot of research dollars that were unavailable to the researcher at the commencement of the study. An integral part of performing research is ensuring that the work is valid, reliable, and complete. Although it is in the nature of many researchers to want to attack and solve all sides of an issue, one must remember that starting with a small piece of the puzzle is not a "bad" way to do science. Having a smaller, but more concentrated study has inevitably changed this research from shaky to solid. It would be beneficial for researchers to research and understand the time and funds that would be required at the outset of the researcher; therefore helping the researcher determine if the resources are available for the current line of study.

### *7.2.2 "Tricks" to Novel Research*

Part of the zealousness of this study included researching a relatively new topic. Although delving into novel research is interesting and exciting, it proved to provide many issues:

- The bank of previous literature was fairly limited.
    - Combined literature reviews (i.e. concurrent review of ASD and technology literature) to combat this issue. For instance, since there were very few studies on the effectiveness of video games for children with ASD, it was necessary to look at past research on more traditional ASD

interventions alongside research on video games in other populations. Future researchers may find this technique helpful in closing some of the gaps found in the current bank of available literature.

- The knowledge base of professionals for advice was very limited.
    - The current study found it very difficult to encounter guidance, being that not many professors or researchers were involved in this multidisciplinary subject. Difficult, yes; however, not impossible. It took the research outside of it's home at Virginia Tech to complete some portions; however, due to some extra legwork and the collaborative nature of research in general, the study was able to receive excellent advice and guidance from professors at the University who specialize in this novel field of gaming, technology, and ASD.

One suggestion for future researchers and institutions concerned with ASD interventions is to have better communication within the field itself. Through many tedious hours, the current research has been able to develop a summary chart of "communities of practice" for the autism and technology field that were encountered during the course of this study, listed in order of discovery:

| **Communities of Practice** | **Related Work** |
|---|---|
| Georgia Institute of Technology | • Autism and Technology Class<br>• Autism Research Group (Human Computer Interaction, Artificial Intelligence, Machine Learning, Mobile and Wearable Computing, etc.) |
| Children's Hospital of Philadelphia (CHOP) | • CHOP and Temple University are currently examining similar computer-based game interventions for augmenting social skills training in children with ASD |
| Temple University | |
| Mercer County Special Services School District (MCSSSD) | • Open to assisting in further ASD and technology research<br>• Currently host computer classes for children and adolescents with ASD, led by a computer specialist |
| University of South Carolina (USC) | • Studying humanoid robots as tools in therapy for children with ASD |

*Table 2: Communities of Practice*

Encountering these "communities of practice" was not an easy task. The key to establishing a relationship with each of the institutions was having a clear goal in mind, an abundant knowledge of the field, and finally, a willingness to alter methodologies to

adhere to the institutions' standards. In the current study, the researcher was able to leverage her many years of experience in working with children with ASD in the solicitation of other institutions' assistance. For researchers without these experiences, it is important to "prove" one's knowledge by having a strong understanding of the current advancements in the field, as well as foundational research. One thing was clear in communication with each university or institution: helping this population is extremely important; therefore, most serious and educated inquiries will be addressed.

Additionally, the researcher found that if certain institutions were not able to assist in the current study, many were willing to direct the researcher to "sister institutions" that could help. It took a lot of effort to establish strong and lasting relationships with the above "communities of practice;" however, being clear about what you need from the relationship, as well as what you will give in return (e.g. recognition, information, findings, data, etc.), is an effective starting point.

*7.2.3 Recruitment Challenges*

At the start of this research, the goal was to have children with ASD test the game. Although that particular goal has since been abolished, the process still added to the "lessons learned" of this study. Working with persons with ASD, especially children, is very difficult. Obtaining IRB approval for such a population requires many safeguards and assurances that there will be no damage to participants whatsoever. In fact, at the commencement of the current study, IRB approval for evaluation with children, the original purpose of the research, took four months to obtain, something that researchers new to this population might not be ready for or expecting. This is not to say that work on special populations should not be done; however, one should be prepared for the additional steps that need to be taken to appropriately study these individuals.

## REFERENCES


Adamson, L.B., Bakeman, R., Decker, D.F., & Romski, M.A. (2009) Joint engagement and the emergence of language in children with autism and down syndrome. *Journal of Autism and Developmental Disorders,* 39.

American Occupational Therapy Association. (2006). Occupational therapy's role with autism. *Occupational Therapy: Skills for the Job of Living.*

American Psychiatric Association. (1980). *Diagnostic and statistical manual of mental disorders*, 3rd ed. Washington, DC: APA.

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (Revised 4th ed.). Washington, DC: APA.

Autism Program at Yale. (2010). Pervasive Developmental Disorder – Not Otherwise Specified (PDD-NOS). *Yale School of Medicine.*

Barr, D.J. (2007). Analyzing 'visual world' eye-tracking data using multilevel logistic regression. *Journal of memory and language, 59*(4), 457-474.

Basak, C., Boot, W.R., Voss, M.W., & Kramer, A.F. (2008). Can training in a real-time strategy video game attenuate cognitive decline in older adults? *Psychology and Aging, 23*(4), 765-777.

Bath, H. (1994). The physical restraint of children: Is it therapeutic? *American Journal of Orthopsychiatry, 64*(1), 40-49.

Behne, T., Carpenter, M., & Tomasello, M. (2005). One-year-olds comprehend the communicative intentions behind gestures in a hiding game. *Developmental Science, 8,* 492-499.

Bechhofer, R.E. (1954). A single-sample multiple decision procedure for ranking means of normal populations with known variances. *The Annals of Mathematical Statistics, 25,* 16-39.

Center for Disease Control and Prevention. (2009). Prevalence of Autism Spectrum Disorders in Multiple Areas of the Unites States, 2004-2006. *Autism and Developmental Disabilities Monitoring Network.*

Center for Universal Design. (1997). The Principles of Universal Design. *Universal Design.*

Cermak, S.A. & Henderson, A. (1990). The efficacy of sensory integration procedures. *Sensory Integration Quarterly,* 1-23.

Colombi, C., Liebal, K., Tomasello, M., Young, G., Warneken, F., & Rogers, S.J. (2009). Examining correlates of cooperation in autism: Imitation, joint attention, and understanding intentions. *Sage Publications and The National Autistic Society, 13*(2), 143-163.

De Leo, G. & Leroy, G. (2008). Smartphones to facilitate communication and improve social skills of children with severe Autism Spectrum Disorder: Special education teachers as proxies. *IDC Proceedings – Workshop on Special Needs. 45-48.*

Demarest. K. (2000). *Video games – What are they good for? Available: http://www.lessontutor.com/kd3.html.*

Francis, P., Firth, L., & Mellor, D. (2005). Reducing the risk of abandonment of assistive technologies for people with autism. *Interact. 1104-1107.*

Ganz, M.L. (2006). The cost of autism. In S.O. Moldin & J.L.R Rubenstein (Eds): *Understanding autism from basic neuroscience to treatment* (pp. 476-498). Boca Raton, Fl.: CRC Press.

Garon, N., Bryson, S.E., & Isabel, M.S. (2008). Executive function in preschoolers: A review using an integrative framework. *Psychological Bulletin, 134*(1), 31-60.

Gazzaniga, M.S., Ivry, R.B., & Mangun, G.R. (2002). *Cognitive neuroscience: The biology of the mind.* New York, NY: Norton.

Gernsbacher, M.A., Stevenson, J.L., Khandakar, S., & Goldsmith, H.H. (2008). Why does joint attention look atypical in autism? *Child Development Perspectives, 2*(1), 38-45.

Greitemeyer, T. & Osswald, S. (2010). Effects of prosocial video games on prosocial behavior. *Journal of Personality and Social Psychology, 98*(2), 211-221.

Griffiths, M. (2003). The therapeutic use of video games in childhood and adolescence. *Clinical Child Psychology and Psychiatry, 8, 547-554.*

Grossberg, S. & Seidman, D. (2006). Neural dynamics of autistic behaviors: Cognitive, emotional, and timing substrates. *Psychological Review, 113*(3), 483-525.

Hale, G.A., Taweel, S.S., Green, R.Z., & Flaugher, J. (1978). *Developmental Psychology, 14*(5), 499-506.

Harvey, M.T., Wong, S.E., & Luiselli, J.K. (2009). Application of applied behavior analysis to mental health issues. *Journal of Psychological Services, 6*(3), 212-222.

Huston, A.C., Wright, J.C., Marquis, J., & Green, S.B. (1999). How young children spend their time: Television and other activities. *Developmental Psychology, 35*(4), 912-925.

Isaksen, J. & Holth, P. (2009). An operant approach to teaching joint attention skills to children with autism. *Behavioral Interventions, 24,* 215-236.

Jacobson, J. W., Mulick, J. A., & Green, G. (1998). Cost benefit estimates for early intensive behavioral intervention for young children with autism—general model and single state case. *Behavioral Interventions, 13,* 201–226.

Kelley, M.E., Shillingsburg, M.A., Castro, M.J., Addison, L.R., LaRue, R.H., & Martins, M.P. (2007). Assessment of the functions of vocal behavior in children with developmental disabilities. *Journal of Applied Behavior Analysis, 40,* 571-576.

Konstantinidis, E.I., Luneski, A., Frantzidis, C.A., Costas, P., & Bamidis, P.D. (2009). A proposed framework of an interactive semi-virtual environment for enhanced education of children with autism spectrum disorders. *The 22nd IEEE International Symposium on Computer-Based Medical Systems, Albuquerque, NM.*

Lavigne, J.V. (1992). Combining self-modeling and stimulus fading in the treatment of an electively mute child. *Psychotherapy: Theory, Research, Practice, Training, 29*(4), 661-667.

Leckman, J.F., Grice, D.E., Boardman, J., Zhang, H., Vitale, A., Bondi, C. … Pauls, D.L. (1997). Symptoms of obsessive-compulsive disorder. *American Journal of Psychiatry, 154,* 911-917.

Lovaas, O.I., Schriebman, L, & Koegel, R.L. (1974). A behavior modification approach to the treatment of autism. *Journal of Autism and Developmental Disorders*, *4*(2), 111-129.

MacDonald, R., Anderson, J., Dube, W.V., Geckeler, A., Green, G., Holcomb, W., Mansfield, & Sanchez, J. (2006). Behavioral assessment of joint attention: A methodological report. *Research in Developmental Disabilities, 27,* 138-150.

Madsen, M., Kaliouby, R., Eckhardt, M., Hoque, M.E., Goodwin, M.S., & Picard, R. (2009). Lessons from participatory design with adolescent of the autism spectrum. *CHI,* 3835-3840.

Martin, G., & Pear, J. (Ed.). (2009). Behavior modification: what it is and how to do it. Upper Saddle River, NJ: Pearson Education, Inc.

Massimi, M. (2007). *Participatory design of mobile phone software for seniors.* Unpublished Master's Thesis. University of Toronto.

Maurice, C., Green, G., & Luce, S.C. (Ed.). (1996). *Behavioral intervention for young children with autism: a manual for parents and professionals*. Austin, TX.: pro-ed.

Millward, C., Ferriter, M., Calver, S., & Connell-Jones, G. (2004). Gluten- and casein-free diets for autistic spectrum disorder (Review). *Cochrane Database of Systematic Reviews, 2,* 1-12.

Moldin, S.O., & Rubenstein, J.L.R. (Ed.). (2006). *Understanding autism: from basic neuroscience to treatment*. Boca Raton, Fl.: CRC Press.

Moore, M. & Calvert, S. (2000). Brief report: Vocabulary acquisition for children with autism: Teacher or computer interaction. *Journal of Autism and Developmental Disorders, 30*(4), 359-362.

Moore, D., Cheng, Y., McGrath, P., & Powell, N.J. (2005). Collaborative virtual environment technology for people with autism. *Focus on autism and other developmental disabilties, 20*(4), 231-243.

Mosconi, M.W., Cody-Hazlett, H., Poe, M.D., Gerig, G., Gimpel-Smith, R., & Piven, J. (2009). Longitudinal study of amygdala volume and joint attention in 2- to 4-year-old children with autism. *Archives of General Psyciatry, 66*(5), 509-516.

Muller, M., and Kuhn, S., (Eds.) Participatory Design. Commun. ACM 36, 4 (June 1993).

Mundy, P., Sigman, M., & Kasari, C. (1990). A longitudinal study of joint attention and language development in autistic children. *Journal of Autism and Developmental Disorders, 20*(1), 115-128.

Murray, D.S., Creaghead, N.A., Manning-Courtney, P., Shear, P.K., Bean, J., & Prendeville, J.A. (2008). The relationship between joint attention and language in children with autism spectrum disorders. *Focus on Autism and Other Developmental Disabilities, 23*(1), 5-14.

Myers, S.M. & Johnson, C.P. (2007). Management of children with autism spectrum disorders. *Journal of the American Academy of Pediatrics, 120*(5), 1162-1182.

Naoi, N., Tsuchiya, R., Yamamoto, J.I., & Nakamura, K. (2008). Functional training for initiating joint attention in children with autism. *Research in Developmental Disabilities, 29,* 595-609.

National Institute of Neurological Disorders and Stroke. (2009) Autism Fact Sheet. *National Institutes of Health.*

National Institute of Neurological Disorders and Stroke. (2009) Rett Syndrome Fact Sheet. *National Institutes of Health.*

Nielsen, J., & Molich, R. (1990). Heuristic evaluation of user interfaces, *Proc. ACM CHI'90 Conf.* (Seattle, WA, 1-5 April), 249-256.

Okolo, C. (1992). The effect of computer-assisted instruction format and initial attitude on the arithmetic facts proficiency and continuing motivation of students with learning disabilities. *Exceptionality, 3, 195–211.*

Pearson, E., & Bailey, C. (2007). Evaluating the potential of Nintendo Wii to support disabled students in education. *Ascilite,* 833-836.

Putnam, C. & Chong, L. (2008). Software and technologies designed for people with autism: What do users want? *ASSETS,* 3-10.

*Robins, D., Fein, D., Barton, M., & Green, J. (2001).* The Modified-Checklist for Autism in Toddlers (M-CHAT): An initial investigation in the early detection of autism and Pervasive Developmental Disorders. *Journal of Autism and Developmental Disorders, 31*(2), 131-144.

Ruff, H.A. & Capozzoli, M.C. (2003). Development of attention and distractibility in the first four years of life. *Developmental Psychology, 39*(5), 877-890.

Rutter, M., Bailey, A., Bolton P., & Couteur, A.L. (1993). Autism: Syndrome definition and possible genetic mechanisms. In R. Plomin & G.E.McClearn (Eds): *Nature, Nurture, & Psychology* (pp. 269-284). Washington, DC: American Psychological Association.

Salley, B., Scarpa, A., & Fenton, K. (2005). A brief review of casein and gluten free diets as an intervention for autism. *Newsbrief, 1*(1), 2-6.

Scassellati, B., Crick, C., Gold, K., Kim, E., Shic, F., & Sun, G. (2006). Social development. *Computational Intelligence Magazine,* 41-47.

Sitdhisanguan, K., Chotikakamthorn, N., Dechaboon, A., Out, P. (2008). Evaluating the efficacy of computer-based training using tangible user interface for low-function children with autism. *Second IEEE International Conference on Digital Game and Intelligent Toy Enhanced Learning,* 70-74.

Smith. (1997). Sexual differences in Pervasive Developmental Disorders (PDD): How girls differ from boys with PDD. *Medscape Psychiatry & Mental Health eJournal, 2*(3).

Thiemann, K.S., & Goldstein, H. (2001). Social stories, written text cues, and video feedback: Effects on social communication of children with autism. *Journal of Applied Behavioral Analysis, 34*(4)*,* 425-446.

Wechsler, D. (2002). The Wechsler Preschool and Primary Scale of Intelligence, Third Edition (WPPSI-III). San Antonio, TX: The Psychological Corporation.

Wegner, D.M., Sparrow, B., & Fuller, V.A. Clever hands: Uncontrolled intelligence in facilitated communication. *Journal of Personality and Social Psychology, 85*(1), 5-19.

Weissenberger, U., & Thompson, C.F. (2009). User-centered design: Getting it right the first time. *SAP AG.*

Werry, I., Dautenhahn, K., Ogden, B., & Harwin, W. (2001). Can social interaction skills be taught by a social agent? The role of a robotic mediator in autism therapy. *Cognitive Technology: Instruments of Mind, 2117,* 57-74.

Wetherby, A. & Prutting, C. (1984). Profiles of communicative and cognitive-social abilities in autistic children. *Journal of Speech and Hearing Research, 27,* 364–377.

Whalen, C., Liden, L., Ingersoll, B., Dallaire, E., & Liden, S. (2006). Behavioral improvements associated with computer-assisted instruction for children with developmental disabilities. *Speech and Language Pathology – Applied Behavior Analysis, 1*(1), 11-26.

Whalen, C. & Schreibman, L. (2003). Joint attention training for children with autism using behavior modification procedures. *Journal of Child Psychology and Psychiatry, 44*(3), 456-468.

Wright, R.D., & Ward, L.M. (2008). *Orienting of attention*. Oxford, England: Oxford University Press.

Wu, M., Baecker, R., & Richards, B. (2005). Participatory design of an orientation aid for Amnesics. *CHI Papers – Assistive Applications. 511- 520.*

# APPENDIX A: DATA COLLECTIONS DOCUMENTS

## *A.1 VT IRB Approval*

VirginiaTech

Office of Research Compliance
Institutional Review Board
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540/231-4606 Fax 540/231-0959
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Website: www.irb.vt.edu

**MEMORANDUM**

**DATE:** July 21, 2010

**TO:** Woodrow Winchester, Jessi Kane

**FROM:** Virginia Tech Institutional Review Board (FWA00000572, expires June 13, 2011)

**PROTOCOL TITLE:** Exploration of Interactive Computer Play in the Training Joint Attention in Young Children with Autism

**IRB NUMBER: 10-619**

Effective July 21, 2010, the Virginia Tech IRB Chair, Dr. David M. Moore, approved the new protocol for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at http://www.irb.vt.edu/pages/responsibilities.htm (please review before the commencement of your research).

**PROTOCOL INFORMATION:**
Approved as: **Expedited, under 45 CFR 46.110 category(ies) 6, 7**
Protocol Approval Date: **7/21/2010**
Protocol Expiration Date: **7/20/2011**
Continuing Review Due Date*: **7/6/2011**
*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

**FEDERALLY FUNDED RESEARCH REQUIREMENTS:**
Per federally regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals / work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

| Date* | OSP Number | Sponsor | Grant Comparison Conducted? |
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*Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irbadmin@vt.edu) immediately.

cc: File
T. Coalson 0118

### A.2 Heuristic Evaluation Questionnaire

Evaluator Name: _____
Evaluator Highest Level of Education: _____
Relevant Certifications: _____
Evaluator Preferred Contact: _____
Date of Evaluation: _____
Time Spent on Game Play: _____

OPENING SCREEN:

1) Variety of Available Characters (i.e. age, race, gender, etc.) for Choosing
   (Low Variation) 1 2 3 4 5 6 7 8 9 10 (High Variation)

2) Clarity of Instructions to Select Character
   (Very Unclear) 1 2 3 4 5 6 7 8 9 10 (Perfectly Clear)

3) Enticement to Play
   (Not Enticing) 1 2 3 4 5 6 7 8 9 10 (Very Enticing)

Clarify Above Responses as Necessary:

_____
_____
_____
_____
_____
_____

LEVEL SCREEN:

1) Similarity to Other Computer Games
   (No Similarities) 1 2 3 4 5 6 7 8 9 10 (Many Similarities)

2) Similarity to Other Video Games
   (No Similarities) 1 2 3 4 5 6 7 8 9 10 (Many Similarities)

3) Clarity of Instructions to Select Level
   (Very Unclear) 1 2 3 4 5 6 7 8 9 10 (Perfectly Clear)

4) Enticement to Continue the Game
   (Not Enticing) 1 2 3 4 5 6 7 8 9 10 (Very Enticing)

Clarify Above Responses as Necessary:

_____

_____
_____
_____
_____
_____

LEVEL 1:

1) Similarity to Other Computer Games
   (No Similarities) 1 2 3 4 5 6 7 8 9 10 (Many Similarities)

2) Similarity to Other Video Games
   (No Similarities) 1 2 3 4 5 6 7 8 9 10 (Many Similarities)

3) Clarity of Instructions on How to Play the Level
   (Very Unclear) 1 2 3 4 5 6 7 8 9 10 (Perfectly Clear)

4) Enticement to Continue Playing the Game
   (Not Enticing) 1 2 3 4 5 6 7 8 9 10 (Very Enticing)

5) Saliency of Scoreboard
   (Not Salient) 1 2 3 4 5 6 7 8 9 10 (Very Salient)

6) Distracting Qualities of Scoreboard
   (Not Distracting) 1 2 3 4 5 6 7 8 9 10 (Very Distracting)

7) Clarity of "Grading" (i.e. Right Answer vs. Wrong Answer)
   (Very Unclear) 1 2 3 4 5 6 7 8 9 10 (Perfectly Clear)

Clarify Above Responses as Necessary:

_____
_____
_____
_____
_____
_____

FADING MECHANISM:

1) Usefulness of Fading Technique
   (Not at all Useful) 1 2 3 4 5 6 7 8 9 10 (Very Useful)

2) Distracting Qualities of Fading Technique

(Not Distracting) 1 2 3 4 5 6 7 8 9 10 (Very Distracting)

3) Appropriateness of Fading Levels
(Inappropriate) 1 2 3 4 5 6 7 8 9 10 (Fully Appropriate)

Clarify Above Responses as Necessary:

_____
_____
_____
_____
_____
_____

POSITIVE REINFORCEMENT:

1) Usefulness of Points as Positive Reinforcement
(Not at all Useful) 1 2 3 4 5 6 7 8 9 10 (Very Useful)

2) Usefulness of Verbal Praise as Positive Reinforcement
(Not at all Useful) 1 2 3 4 5 6 7 8 9 10 (Very Useful)

Clarify Above Responses as Necessary:

_____
_____
_____
_____
_____
_____

LEVEL CHANGE:

1) Level Change Screen as a Reward
(Not Rewarding) 1 2 3 4 5 6 7 8 9 10 (Very Rewarding)

2) Appropriateness of Videos as a Reward
(Inappropriate) 1 2 3 4 5 6 7 8 9 10 (Fully Appropriate)

Clarify Above Responses as Necessary:

_____
_____
_____
_____

_____

_____

LEVEL 2:

1) Similarity to Other Computer Games
   (No Similarities) 1 2 3 4 5 6 7 8 9 10 (Many Similarities)

2) Similarity to Other Video Games
   (No Similarities) 1 2 3 4 5 6 7 8 9 10 (Many Similarities)

3) Clarity of Instructions on How to Play the Level
   (Very Unclear) 1 2 3 4 5 6 7 8 9 10 (Perfectly Clear)

4) Enticement to Continue Playing the Game
   (Not Enticing) 1 2 3 4 5 6 7 8 9 10 (Very Enticing)

5) Saliency of Scoreboard
   (Not Salient) 1 2 3 4 5 6 7 8 9 10 (Very Salient)

6) Distracting Qualities of Scoreboard
   (Not Distracting) 1 2 3 4 5 6 7 8 9 10 (Very Distracting)

7) Clarity of "Grading" (i.e. Right Answer vs. Wrong Answer)
   (Very Unclear) 1 2 3 4 5 6 7 8 9 10 (Perfectly Clear)

8) Degree of Change in Difficulty (From Level 1)
   (Too Low) 1 2 3 4 5 6 7 8 9 10 (Too High)

Clarify Above Responses as Necessary:

_____

_____

_____

_____

_____

_____

LEVEL 3:

1) Similarity to Other Computer Games
   (No Similarities) 1 2 3 4 5 6 7 8 9 10 (Many Similarities)

2) Similarity to Other Video Games
(No Similarities) 1 2 3 4 5 6 7 8 9 10 (Many Similarities)

3) Clarity of Instructions on How to Play the Level
(Very Unclear) 1 2 3 4 5 6 7 8 9 10 (Perfectly Clear)

4) Enticement to Continue Playing the Game
(Not Enticing) 1 2 3 4 5 6 7 8 9 10 (Very Enticing)

5) Saliency of Scoreboard
(Not Salient) 1 2 3 4 5 6 7 8 9 10 (Very Salient)

6) Distracting Qualities of Scoreboard
(Not Distracting) 1 2 3 4 5 6 7 8 9 10 (Very Distracting)

7) Clarity of "Grading" (i.e. Right Answer vs. Wrong Answer)
(Very Unclear) 1 2 3 4 5 6 7 8 9 10 (Perfectly Clear)

8) Degree of Change in Difficulty (From Level 2)
(Too Low) 1 2 3 4 5 6 7 8 9 10 (Too High)

9) Degree of Realism
(Low) 1 2 3 4 5 6 7 8 9 10 (High)

10) Ability to Generalize Skill to Everyday Life
(Cannot Generalize) 1 2 3 4 5 6 7 8 9 10 (Generalizes Well)

Clarify Above Responses as Necessary:

_____
_____
_____
_____
_____
_____

ON-GOING ADDITIONAL COMMENTS

_____
_____
_____
_____
_____

## *A.3 Informed Consent, Heuristic Evaluation*

**Department of Industrial and Systems Engineering**
**Virginia Polytechnic and State University**
**Blacksburg, Va. 24061**

**Training Joint Attention in Young Child with Autism through Interactive Online Play**

Dear Professional/Student Evaluator,

I am a graduate student in the Department of Industrial and Systems Engineering at Virginia Polytechnic and State University conducting research on the effects of online game play on joint attention skills of young children with ASD (Autism Spectrum Disorder) under the supervision of Dr. Woodrow Winchester III. Joint attention is defined as the process by which one alerts another to a stimulus via nonverbal communication, such as gazing or pointing. For example, one may gaze at another person, point to an object, then gaze back to the other person, ensuring they are sharing attention on the object. The purpose of this study is to gather information based on your knowledge and the knowledge of other professionals and students with experience in this field. The information this research aims to collects involves the following: What elements of the game will be successful for a child with an ASD; What elements will hinder the learning the process for a child with an ASD, What design elements should be included/not included; etc. The study is aiming to recruit a total of 25-30 evaluators for this research. Any professional or student in the field of psychology, education, and engineering who has experience with the ASD population will be permitted to participate.

All participating evaluators will be given an evaluation sheet. On this sheet, the researchers ask that you provide your name and contact information, should we need to contact you to clarify any of your responses. If you are not comfortable doing this, please inform the researcher at this time, and you will be dismissed from the study. If you choose to move forward, but decide to withdraw your information at a later date, please contact the researcher immediately and your information will be destroyed at once. Only researchers directly involved in this study will have access to the data. It is possible that the Institutional Review Board (IRB) may view this study's collected data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research. Results will only be reported in the form of group data and if specific quotations from the evaluations are utilized, no identifying information will be provided. All identifying information will be retained for the duration of one year following the completion of the study. After this time, all hardcopy data will be shredded and all softcopy data will be permanently deleted.

After you are given the evaluation sheet, you will be instructed to click on the game icon on the researcher's computer. Once you do this, the game itself will instruct you on how to continue. If you have any questions, please direct them to the researcher at any time during the study. The evaluation process should take about 20 minutes from start to finish.

It is the researchers' hope that the results of this study may help future researchers to better understand the ability of certain design elements in virtual gaming to either help or hinder in the instruction of social skills of young child with ASD. Increased understanding in this field will serve as a framework to begin producing this type of technology and eventually lower costs associated with caring for someone with ASD.

You have the right to withdraw consent of your participation at any time without consequence. Also, you are free not to answer any questions that you may not feel comfortable with without penalty.

Virginia Tech Institutional Review Board: Project No. 10-619
Approved July 21, 2010 to July 20, 2011

There are no more than minimal risks in participation in this study. You will be compensated $10 for the evaluation session that you attend.

If you have any questions about this research protocol, please contact me at (609) 227-1478 or my faculty supervisor, Dr. Winchester, at (540)-231-5936.

---

I have read the Consent Form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my, _____, voluntarily consent to participate in Jessi Kane's study of virtual gaming in the training of joint attention in young children with ASD.

_____ _____
Name Date

If I should have any questions about the protection of human research participants regarding this study, I may contact Dr. David Moore, Chair Virginia Tech Institutional Review Board for Protection of Human Subjects, telephone: (540) 231-4991; email: moored@vt.edu; address: Office of Research Compliance, 2000 Kraft Drive, Suite 2000 (0497), Blacksburg, VA 24060.

Group results of the study will be available in December 2010.
If you would like to receive a copy, please provide an email address at which we may send it to you:
_____.

## *A.4 Informed Consent, Participatory Design Group*

**Department of Industrial and Systems Engineering**
**Virginia Polytechnic and State University**
**Blacksburg, Va. 24061**

**Training Joint Attention in Young Child with Autism through Interactive Online Play**

Dear Evaluator,

I am a graduate student in the Department of Industrial and Systems Engineering at Virginia Polytechnic and State University conducting research on the effects of online game play on joint attention skills of young children with ASD (Autism Spectrum Disorder) under the supervision of Dr. Woodrow Winchester III. Joint attention is defined as the process by which one alerts another to a stimulus via nonverbal communication, such as gazing or pointing. For example, one may gaze at another person, point to an object, then gaze back to the other person, ensuring they are sharing attention on the object. The purpose of this study is to gather information based on your knowledge and the knowledge of other professionals and students within this area of study. The information this research aims to collects involves the following: What elements of the game will be successful for a child with an ASD; What elements will hinder the learning the process for a child with an ASD, What design elements should be included/not included; etc. The study is aiming to recruit a total of 6 subject matter experts for this research. Any professional or student in the field of psychology, education, and engineering will be permitted to participate.

All participating evaluators will gather on Virginia Tech's campus. A paper storyboard of the game design will be presented. Discussion format will follow in which each representative of each different field will give opinions and eventually come to a conclusion on the format of the design. Only researchers directly involved in this study will have access to the study's data. It is possible that the Institutional Review Board (IRB) may view this study's collected data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research. Results will only be reported in the form of group data and if specific quotations from the evaluations are utilized, no identifying information will be provided. All identifying information will be retained for the duration of one year following the completion of the study. After this time, all hardcopy data will be shredded and all softcopy data will be permanently deleted.

The group discussion should take about 2 hours from start to finish.

It is the researchers' hope that the results of this study may help future researchers to better understand the ability of certain design elements in virtual gaming to either help or hinder in the instruction of social skills of young child with ASD. Increased understanding in this field will serve as a framework to begin producing this type of technology and eventually lower costs associated with caring for someone with ASD.

You have the right to withdraw consent of your participation at any time without consequence. Also, you are free not to answer or respond to any questions that you may not feel comfortable with without penalty. There are no more than minimal risks in participation in this study.

If you have any questions about this research protocol, please contact me at (609) 227-1478 or my faculty supervisor, Dr. Winchester, at (540)-231-5936.

Virginia Tech Institutional Review Board: Project No. 10-619
Approved October 21, 2010 to July 20, 2011

I have read the Consent Form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my, _____, voluntarily consent to participate in Jessi Kane's study of virtual gaming in the training of joint attention in young children with ASD.

_____ _____
Name Date

If I should have any questions about the protection of human research participants regarding this study, I may contact Dr. David Moore, Chair Virginia Tech Institutional Review Board for Protection of Human Subjects, telephone: (540) 231-4991; email: moored@vt.edu; address: Office of Research Compliance, 2000 Kraft Drive, Suite 2000 (0497), Blacksburg, VA 24060.

Group results of the study will be available in December 2010.
If you would like to receive a copy, please provide an email address at which we may send it to you: _____.

### *A.5 Schedule of Design Elements*

- Opening Screen **5 MINUTES**
    - Similarity to computer/video games
        - Motivation to play
- Level Selection Screen **3 MINUTES**
    - Similarity to computer/video games
        - Motivation to play
- Level 1 Selected Screen **6 MINUTES**
    - Similarity to computer/video games
        - Motivation to play
    - Distraction points/focal points (looking for a small ratio)
    - Appropriateness of design for the skill it is intending to help children practice (i.e. gaze following)
- Level 1 Instructions Screen **5 MINUTES**
    - Clarity and presentation (verbal vs. written) of instructions
- Level 1 Fading **10 MINUTES**
    - Needs redesign and must:
        - Not be distracting
        - Be informative
        - Be clearly indicating the correct answer selection
- Level 1 Correct Answer Screen **10 MINUTES**
    - Similarity to computer/video games
        - Challenge/frustration
    - Appropriateness of the "grading" procedure for this population
    - Placement of scoreboard
        - 30 correct answers are needed to move to next level
            - Heuristic evaluation determined this was too many in a sequence
                - Based on literature, need at least 30 trials

- How can this be appropriately divided such that "boredom" does not occur?

- Level 1 Wrong Answer Screen **5 MINUTES**
  - Similarity to computer/video games
    - Challenge/frustration
  - Appropriateness of the "grading" procedure for this population
- Level Change Screen (same between Level 1 and 2, as 2 and 3)
  - Shown for sequence, but not seeking re-design as was graded very high on all positive attributes under the heuristic evaluation
- Level 2 Instructions Screen **5 MINUTES**
  - Clarity and presentation (verbal vs. written) of instructions
- Level 2 Fading **5 MINUTES** (should be consistent with Level 1; therefore, needs less time)
  - Needs redesign and must:
    - Not be distracting
    - Be informative
    - Be clearly indicating the correct answer selection
- Level 2 Selected Screen **6 MINUTES**
  - Similarity to computer/video games
    - Motivation to play
  - Distraction points/focal points (looking for a small ratio)
  - Appropriateness of design for the skill it is intending to help children practice (i.e. gaze following)
- Level 2 Correct Answer Screen **5 MINUTES** (should be consistent with Level 1; therefore, needs less time)
  - Similarity to computer/video games
    - Challenge/frustration
  - Appropriateness of the "grading" procedure for this population
  - Placement of scoreboard
    - 30 correct answers are needed to move to next level

        - Heuristic evaluation determined this was too many in a sequence
            - Based on literature, need at least 30 trials
            - How can this be appropriately divided such that "boredom" does not occur?
- Level 2 Wrong Answer Screen **5 MINUTES**
    - Similarity to computer/video games
        - Challenge/frustration
    - Appropriateness of the "grading" procedure for this population
- Level Change Screen (same between Level 1 and 2, as 2 and 3)
    - Shown for sequence, but not seeking re-design as was graded very high on all positive attributes under the heuristic evaluation
- Level 3 Instructions Screen (CAREFUL: instructions significantly change here) **5 MINUTES**
    - Clarity and presentation (verbal vs. written) of instructions
- Level 3 Fading (Should be the same as Level 1 and 2, but open to change for "realism" qualities of this level) **5 MINUTES**
    - Needs redesign and must:
        - Not be distracting
        - Be informative
        - Be clearly indicating the correct answer to be selected
- Level 3 Selected Screen **5 MINUTES**
    - Distraction points/focal points (looking for a small ratio)
    - Appropriateness of design for the skill it is intending to help children practice (i.e. gaze following)
        - Ability to generalize skill to "real world"
- Level 3 Correct Answer Screen **5 MINUTES**
    - Similarity to computer/video games
        - Challenge/frustration
    - Appropriateness of the "grading" procedure for this population
    - Placement of scoreboard

        - 30 correct answers are needed to complete this level
            - Heuristic evaluation determined this was too many in a sequence
                - Based on literature, need at least 30 trials
                - How can this be appropriately divided such that "boredom" does not occur?
- Level 3 Wrong Answer Screen **5 MINUTES**
    - Similarity to computer/video games
        - Challenge/frustration
    - Appropriateness of the "grading" procedure for this population

### *A.6 ABA Appropriation Evaluation*

**ABA EVALUATION**

Name:_____

Parent or Teacher:_____

Experience with ABA:

_____
_____
_____
_____
_____

Experience with Autism Spectrum Disorder (ASD):

_____
_____
_____
_____

Date of Evaluation:_____

Close-ended Questions:

1) Use of Video Games to Teach Children with ASD?
   (Inappropriate) 1 2 3 4 5 6 7 8 9 10 (Appropriate)

2) Use of Computer Games to Teach Children with ASD?
   (Inappropriate) 1 2 3 4 5 6 7 8 9 10 (Appropriate)

3) Current Game's Ability to Encompass Traditional ABA Practices?
   (Unable) 1 2 3 4 5 6 7 8 9 10 (Very Able)

4) Current Game Design's Ability to Teach Social Skills to Children with ASD?
   (Unable) 1 2 3 4 5 6 7 8 9 10 (Very Able)

5) Current Game's Ability to Teach Gaze Following to Children with ASD?
   (Unable) 1 2 3 4 5 6 7 8 9 10 (Very Able)

   ____ Leave Question Blank and Check Here if Unfamiliar with Gaze Following

Open-ended Questions

1) What do you think of the current game's ability to use traditional ABA practices?

2) How well do you think the ABA practices were translated into game format?

3) Please comment on the appropriateness of a video/computer game in ASD intervention?

4) Please comment on the ability of video/computer games to augment social skills?

5) PARENTS, would you choose to use this type of intervention with your child? Explain.

6) TEACHERS, would you choose to use this type of intervention in the classroom? Explain.

## *A.7 Informed Consent, ABA Appropriation Evaluation*

**Department of Industrial and Systems Engineering**
**Virginia Polytechnic and State University**
**Blacksburg, Va. 24061**

**Training Joint Attention in Young Child with Autism through Interactive Online Play**

Dear Evaluator,

I am a graduate student in the Department of Industrial and Systems Engineering at Virginia Polytechnic and State University conducting research on the effects of online game play on joint attention skills of young children with ASD (Autism Spectrum Disorder) under the supervision of Dr. Woodrow Winchester III. Joint attention is defined as the process by which one alerts another to a stimulus via nonverbal communication, such as gazing or pointing. For example, one may gaze at another person, point to an object, then gaze back to the other person, ensuring they are sharing attention on the object. The purpose of this study is to gather information based on your knowledge and the knowledge of other professionals and students within this area of study. The information this research aims to collects involves the following: What elements of the game will be successful for a child with an ASD; What elements will hinder the learning the process for a child with an ASD, What design elements should be included/not included; etc. The study is aiming to recruit a total of 6 or more subject matter experts for this research. Any individual with experience in the field of psychology, education, and ABA/Autism will be permitted to participate.

All participating evaluators will gather on Mercer County Special Services School District's campus. A paper storyboard of the game design will be presented, along with the Flash® prototype. Discussion format will follow in which each representative of each different field will give opinions and eventually come to a conclusion on the format of the design. Only researchers directly involved in this study will have access to the study's data. It is possible that the Institutional Review Board (IRB) may view this study's collected data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research. Results will only be reported in the form of group data and if specific quotations from the evaluations are utilized, no identifying information will be provided. All identifying information will be retained for the duration of one year following the completion of the study. After this time, all hardcopy data will be shredded and all softcopy data will be permanently deleted.

The group discussion should take about 2 hours from start to finish.

It is the researchers' hope that the results of this study may help future researchers to better understand the ability of certain design elements in virtual gaming to either help or hinder in the instruction of social skills of young child with ASD. Increased understanding in this field will serve as a framework to begin producing this type of technology and eventually lower costs associated with caring for someone with ASD.

You have the right to withdraw consent of your participation at any time without consequence. Also, you are free not to answer or respond to any questions that you may not feel comfortable with without penalty. There are no more than minimal risks in participation in this study.

If you have any questions about this research protocol, please contact me at (609) 227-1478 or my faculty supervisor, Dr. Winchester, at (540)-231-5936.

Virginia Tech Institutional Review Board: Project No. 10-619
Approved February 11, 2011 to July 20, 2011

I have read the Consent Form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my, _____, voluntarily consent to participate in Jessi Kane's study of virtual gaming in the training of joint attention in young children with ASD.

_____ _____
Name Date

If I should have any questions about the protection of human research participants regarding this study, I may contact Dr. David Moore, Chair Virginia Tech Institutional Review Board for Protection of Human Subjects, telephone: (540) 231-4991; email: moored@vt.edu; address: Office of Research Compliance, 2000 Kraft Drive, Suite 2000 (0497), Blacksburg, VA 24060.

Group results of the study will be available in March 2011.
If you would like to receive a copy, please provide an email address at which we may send it to you:
_____.

Virginia Tech Institutional Review Board: Project No. 10-619
Approved February 11, 2011 to July 20, 2011