Digital Tools for Children with Autism:

Enhancing sensory development and the recognition of faces and emotions

by

Mehnaz Aydemir

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Digital Tools for Children with Autism: Enhancing sensory development and the recognition of faces and emotions Mehnaz Aydemir, Master of Design in Digital Futures, OCAD University, 2016

This thesis creates a personal sensory environment and app for children aged six to eleven with Autism Spectrum Disorder (ASD) in order to stimulate and teach facial and emotional recognition in others. This thesis also suggests that children with autism and their macro and micro social connections exhibit a communication difference that is interpreted as a communication problem or gap by neuro-typical people. It is suggested in this thesis that if neuro-typical people can exhibit empathy for the different communication practices of children with autism, this awareness may create a better environment for the development of autism therapies. This thesis project recognizes that children with autism live in a predominantly neuro-typical world and experience expectations of neuro-typical individuals; as such, the tools presented here are designed with the intention to assist children with autism to communicate well in their environment so that they can feel more confident and fulfilled.

Keywords: Autism spectrum disorder, Sensory development, Facial recognition, Emotional recognition, Mood rooms, Sensory rooms, Autism apps, Cocoon chair, Puzzle app, Autism LED Lights

To my beautiful daughters, my muses, Mina and Meylin

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and also thanks to magic of blue...

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Introduction

My background in Industrial Design has led me to pursue the idea of creating products that matter to people, following the central tenet that form follows function.

This thesis assumes that neuro-typical people are responsible for understanding and responding to kids with autism in their communication practices and seeks to enable children with ASD the ability to practice standard communication and recognize faces and emotions in order to improve social communications with individuals who do not understand autistic communication.

Research shows that children who experience a lack of sensory development develop problems in education and learning (Bennet Brown, N., Dunn, W. 2010). High and mid-functioning autistic children have many social and emotional challenges, one of which is a difficulty in recognizing faces. Facial and emotional recognition in autism were first studied by Tim Langdell, a Psychologist at University College in London, in 1978 who studied two groups of children with autism who where tasked with identifying people’s faces in photographs. His research shows that once the faces were selectively concealed—for instance, revealing pieces of the mouth or eyes separately— problems began to occur in the way people with autism process and understand the faces under examination. Both adult and child participants found that identifying faces using the eyes was easier when compared to other features of the face. Furthermore, behavioural studies and neuroimaging findings show that problems in the processing of facial recognition are a result of both a natural impairment in neural systems and a consequence of limited social interest. These findings suggest that early age experiences with faces can specifically help to improve this important developmental skill in many children with autism. Many children with autism may show central nervous system irregularities that can affect the required visual input that allows for face recognition. This may, as well, limit the visual understanding that is required for the development and activation of facial processing in the nervous system (Sasson, N.J., 2006). Also, many other issues can result in development of facial processing due to the lack of auditory, visual, touch, and other sensory stimuli. Facial and emotional recognition problems can create large amounts of stress on many children with autism. Through under- or over-stimulation, they may become exhausted and find it difficult to cope with daily routines. Many children with autism may also miss developmental milestones in transitions, certain activities, locations, people and having to deal with certain constituents, such as elements of conversations or tasks (Notbohm E., 2005).

As will be shown in this thesis research, there is great opportunity for positive interventions in the facial and emotional recognition in a sensory processing environment for some children with autism through this thesis research. This thesis creates an environment that includes facial recognition tools while supporting sensory issues, like auditory, touch and visual, with digital technology and digital feedback. The project combines two development therapies under the same roof—facial and emotional recognition and sensory development—in order to produce faster and more measurable results in interventions.

Many children with autism have problems connecting with others and experiencing empathy. They are expected to show empathy by others who do not understand the behaviors of autism. As stated earlier, if neuro-typical people can understand the communication practices of children with autism better, they are more likely to appreciate the differences that autism brings. I hope neuro-typical people will accept differences, as mainstream society has not achieved this yet. This project helps kids to recognize faces and moods. This thesis seeks to create a connection between face and emotion recognition and sensory satisfaction in order to enhance learning with the help of sensory stimuli. In using a controlled sensory development environment, many children with autism become relaxed and stimulated enough to learn facial and emotional recognition more easily. This following research addresses some of the problems experienced by autistic children, and responds by creating a sensory environment and app that offers features of digital learning; it is hoped that this research will help these kids to learn necessary context better and will create a relaxed and fun environment just for the benefits of free play.

2. What is Autism

According to Nothbohm’s study, the autism spectrum is a neurodevelopmental condition that is complex and life-long with differing individual responses to seeking, avoiding, sensitivity and registration of information in every case (Notbohm E., 2005). Autism, as defined in neurodevelopmental disorder by researchers, is a Pervasive Developmental Disorder (PDD). This means that children with autism show delays in many areas of neurological development. Some symptoms might fade away while others might appear later in life (Berger, 2002). The many varied social challenges of children with autism make it difficult for them to integrate and learn in their environment. I am addressing these kids as having developmental "disorders" because I want to give them mainstream communication tools to assist with their social challenges in order to better communicate in their environment. Autism is considered a spectrum disorder because it is not limited to a specific delay in development, but rather it is a group of complex brain development disorders. In the United States, autism is found 1 in 150 births, affecting more boys than girls (4.8:1; Centers for Disease Control and Prevention [CDC], 2007).

Autism is characterized by impairments in social skills, nonverbal and verbal communication that also involve repetitive behaviors and unusual physical and emotional interests. This means that there are delays in certain areas of development that interfere with developmental functioning during a child's growth. The spectrum has a large variety of symptoms including cognitive and sensory problems, tantrums, defensiveness and aggression.

2.1 Symptoms

Autism symptoms are varied according to each individual child (Adrien, J. L. et al. 1993). In general, children experience several types of behavior related issues such as differences in social skills, communication, and attention as well as muscle activity issues. These issues occur starting from infant years, followed by other patterns of behavior during the second year of life in addition to those already found. Gaze avoidance, hyper activity, and lack of emotional expressions occur in the second year that become persistent issues that build upon any previous findings in early infant stages (Adrien, J. L. et al. 1993). These findings show evidence where children with autism have a lack of development such as the recognition of faces and emotions. Autism symptoms cause difficulty processing sensory information such as textures, sounds, smells, tastes, brightness and movement. Some children with autism also have sensory abnormalities such as insensitivity to pain, and uncharacteristic responses to auditory, visual, or physical stimuli (Leekam, S.R., Nieto, C., Libby, S.J., Wing, L., Gould, J., 2006). Due to the symptoms above, many children with autism can have communication problems, which can interfere with daily functioning, causing isolation. Sensory issues and problems are strongly correlated to the specific interests and condition of individuals with autism. Individuals with autism experience a range of challenges in building social skills, including the communication and expression of ideas and emotions and understanding facial expressions, anxiety over new faces or places, accurately remembering faces fully, lacking perspective and not being able to see or picture an environment or situation fully, as well as social-interpersonal skills like starting and maintaining conversations, turn-taking and appropriate social responses, making and maintaining eye contact, and reciprocity (Gray, C., 2010). According to studies, without appropriate intervention, these symptoms may interfere with their daily life and may be difficult to change. Problematic behaviors may include having tantrums at dinner time, not wanting to go to bed, and unexplained aggressiveness (Ryan, C., Caitriona Ni Charragain, 2010). Each of these behaviours takes time and energy for parents to communicate, understand and help the child overcome, with interventions leading to children experiencing better social and behavioural outcomes. Outcomes problematic behaviours can range from mild to strong and are specific to individual tastes for food, activity choices, toys and levels of sensitivity to the auditory, visual or touch senses. (Ospina MB, Krebs Seida J, Clark B, Karkhaneh M, Hartling L, 2008). Appropriate interventions bring opportunities to ease children’s daily life and also create better options for parents to help their children. The causes of autism are unknown according to Canadian, Californian and West Australian data, as there is not enough evidence of sociological and environmental factors to explain the actual causes of autism spectrum disorder (Deisher, T.A., Doan, N.V., 2015).

3. Autism research – Behavior and social issues

Most people with ASD find that social interactions leave them uncomfortable and challenged (Hardy, L. 2015). When it comes to social skills, there are select appropriate strategies that are thought to improve daily life and social communication for those with ASD. Social interactions are researched and identified by Carol Gray, Director of the Gray Center for Social Learning and Understanding in Grand Rapids, Michigan, who as a teacher developed the social skills concept to improve the social lives of children with autism; she explains that social deficiency in autism may be more manageable and less severe if "neuro-typical" people can help create better communication and "social systems" through patience and engagement (Dant, T., 2014, 57-58). In everyday life, many children with autism have difficulties with language, manipulating objects in three dimensional space, and/or learning mathematical skills (again, differing for each individual), which can be improved through practice. People with ASD cannot connect emotionally to develop empathy with others because their consciousness is very directed (Wigmore, S., 2010). Knowing people's desires and emotions by experiencing the moment with perception, engages the ASD subject in the collection of registered data so that s/he can recognize the situation when it occurs again in the future. I hope that children with autism will be able to understand the differences between emotions using the interventions suggested here. This would be an important and meaningful milestone in communicating with their families and environment. As stated above, children with ASD cannot learn empathy as autistic minds are primarily systemic, showing "zero-positive empathy" (Baron-Cohen, S. 2011). They cannot create empathy but they can act from learned behaviors and from "zero-positive" patterns. If neuro-typical individuals can try to act from a no "I" point—meaning that they try to see from the others' (ASD child's) perspective, or act from a place of—we may increase awareness and empathy toward those with autism. (Baron-Cohen, S. 2011). Other's awareness can bring children with autism a chance to connect with trust. It is neuro-typical people who should put forward the effort to change perspective away from mainstream expectations toward those with autism as they are unable to do so on account of ASD.

As we focus on teaching children with ASD social connectivity and developing therapies for teaching them empathy, we often forget to educate society-at-large of the need for empathy for those with autism. The way we speak to people with ASD is also part of the problem that affects and changes how communication shapes most (ASD) children's understanding. According to Carol Gray, if we observe communications between neuro-typical people and most children with ASD, autistic minds' rate of understanding turns out to be approximately 7% of what is said, 38% of how something is said, and 55% of what is liked or how someone is acting while something is being stated (Gray, C., 2010).

This question of communicating with autistic minds arose during the 2015 workshop series on Social Skills and Communication in Autism lecture run by Lynn Hardy at Kerry's Place Mississauga Workshops in November 2015. I was expecting to learn what the specific challenges that most children with ASD experience in their social communication are and how to respond to their needs. What I learned from this experience was that neuro-typical people's reflections can add positive steps to the process of learning in autistic minds.

Social communication and/or social skills deficiency is a combination of situations that occur between two or more people that leads to the children involved feeling either positively or negatively about the interaction. There are four social skill areas that are important to many children on the autism spectrum: survival skills, interpersonal skills like joining in an activity, problem solving skills, and the ability to ask for help. Apologizing, accepting consequences, and conflict resolution skills that deal with teasing, loss or losing in games, being left out, and feelings of peer pressure are all areas of social communication development in most children with ASD that need to be improved (Gray, C., 2010).

One study shows that emotion recognition training is focused on facial expressions. The study was done with children aged between 4-7. The term 'social skills' contains a wide range of abilities that incorporates listening and speaking skills, including the ability to distinguish and understand emotional facial expressions, gesture, posture, and proximity. Emotion recognition plays a critical role as a teachable skill for children and people with ASD to be able to understand social interactions in their daily lives (Baron-Cohen 2002). Deficiencies with regulating sensory input have been investigated many times and recorded to explain the characteristics of autism (Kientz & Dunn, 1997); in fact, these are problems that have been documented by people with autism themselves. The occurrence of sensory processing problems such as responding to stimuli, hyper responsiveness, and the closing of ears to sounds is documented in autism literature ranging from 42% to 88% of all study participants (Baranek, 2002; Kientz & Dunn, 1997; LeCouteur et al., 1989; Volkmar, Cohen, & Paul, 1986; Watling et al., 2001). Distinctions in hearing processing are one of the common known sensory processing disorders according to Stanley Greenspan M.D. and Serena Weider (1997), both of whom are psychiatrists, who reported that 100% of the participants struggled with hearing and responding, with many researchers also reporting “auditory hypersensitivity” (Tomchek S.D., Dunn W, 2007). Unpredictable visual responses are also reported in the literature, showing that those with ASD tend to avoid eye contact and eye gazing in accordance with the lack of social skills in autism (Tomchek S.D., Dunn W, 2007). Sensory deficiency findings of participants who joined the study show results that ranged from no response to sound (81%), sensitivity to loud noises (sound that is louder than comfortable listening level) (53%), to visual review of hands or fingers (62%), and arm flapping (52%) (Volkmar et al., 1986). Sensory processing of most children with autism includes: sensory seeking, emotionally reactive, low endurance/tone, oral sensitivity, inattention/distractibility, poor registration, fine-motor/perceptual skills, and others. Mayes and Calhoun (1999) showed in their study that 100% of children with autism had 1 or more of the 10 symptoms in a somatosensory disturbance subscale – averaging 6.2 symptoms – of an autism diagnostic screener. A love of movement, roughhouse play, and climbing (91%); atypical feeding patterns (75%); unresponsiveness to verbal input (71%); and unusual sensory inspection of objects (68%) were the most commonly reported items of study reported by Mayes and Calhoun (1999) (Tomchek S.D., Dunn W, 2007).

Given the many issues experienced by study groups, there is evidence that there is ample opportunity for intervention with kids on the autistic spectrum in order to help improve learning face and emotion recognition in a sensory environment. Areas under investigation in this thesis work through the issues associated with facial and emotional recognition in a sensory stimulation environment to create positive learning outcomes for most children with ASD. A key area that needs a solution is the facial and emotional recognition problem. This problem can be solved by addressing sensory processing issues. Once a child's sensory needs are satisfied they can learn a given task better (Dunn, W.,1997). Many individuals with autism are not able to process the complex visual patterns of emotions in the face as well as the complex nuances of language, including nonverbal communication due to sensory overstimulation, which is why detecting and understanding emotions in others can be a challenge. Research shows that sensory issues affect children with autism negatively for creating and learning in their environment as the missing parts create shortfalls in their communication with others. After reviewing the above findings, I decided to investigate potential methods that might help satisfy stimuli for my user participant.

4. What is play therapy, and which development therapies can we use for children with ASD in this research?

This thesis includes some tools in the form of a puzzle game and playful lights and music as rewards for completion of the game. Play therapy is a guided counselling therapy that is based on a developmental understanding of children and the constructive role of play in their growth and development. The interventions found in this thesis are informed by research in play therapy and are guided by a therapist's suggestions. The therapists' comments about how this research is related to directed play therapy can be found in the appendix section of this paper. I will explain her thoughts here: Jennifer Cuellar uses Natural Environment Teaching (NET) and Student Led Learning in her therapies, which can be applied as play therapy interventions when needed. Her contribution to play therapy sessions in this research can be seen in the pairing of fun activities with the targeted skills that she is trying to teach. Embedding a learning activity in a fun activity helps maximize session time, otherwise it is best to apply the learning activity first, followed by a reward activity so that development can be measured (Cuellar, J., 2016). Young children have limited ability to express their feelings and concerns well enough through words alone. Play therapy provides children an expressive, nonverbal communication environment that crosses language and cultural barriers (Roy, S. 2006). Play therapy is a relational process occupational therapy conducted under the supervision of a trained therapist. There are specific play therapies for children with autism like directive and non-directive therapies. Through play, children are encouraged to lower their emotional barriers to better express their feelings. Additionally, the active processes of play help to relieve and move past stresses and trauma (Mulherin, 2001). "For play to be beneficial from a therapeutic viewpoint, it should include opportunities for diagnostic assessment, a working relationship with the therapist, a breaking down of defences, facilitating articulation, and preparing the child for future life events" (Mulherin, 2001). Under a trained therapist, play therapy is also a great tool for parents to experience how to generate positive manageable relations with their children. Play is an important developmental tool for children because it stretches a child's abstract thinking to support their objective observations of the world, and provides the opportunity to explore the differences between complex reality and abstract experiences, learn controlling actions and gain coping skills. The diverse benefits of play include improving emotional expression, helping to develop problem solving skills, coping with emotions, and developing resilience. Play therapy provides a useful approach to designing a learning environment for kids with autism with the important benefit of creating a safe space to express emotions. This thesis proposes that by using play therapy approaches in a sensory stimuli environment, many children with autism can show development of focusing on learning. There are two main types of therapies to be used in autism therapies; Directive Play Therapy (DPT) and Non-Directive Play Therapy (NDPT). Non-Directive Play Therapy uses individual play while the therapist observes the child in a reflective listening mode attentive to the child's expressed behaviours, seeking to understand ideas and offer them back to the child. In Directive Play Therapy, the therapist directly encourages the child to specific play activities with specific directions. Both directive and non-directive play therapies are well suited to autism interventions. Facial recognition and emotional development therapy, with the support of an environment that encourages sensory development, falls under Directive Play Therapy. I chose to employ Guided DPT therapy in this research, as directed by therapist Jennifer Cuellar, an expert in ABA therapies (Applied Behavioural Therapy). Chin and Tsuei's studies show that DPT helps children who have behavioural, emotional and traumatic issues, smooth children's learning of coping skills, and show that the use of DPT specifically improves learning in children with ASD (Chin and Tsuei 2014).

5. Designing for Physical surroundings

To create the best learning environment for many children with autism, we have to make sure that the physical surroundings are comfortable and encouraging (Ginsburg, E.,1997). Many children with autism have a very short attention span for looking at (people's) faces, finding it a challenge to recognize faces, even when they are familiar and seen daily. For instance, a neighbour or a family friend might make regular daily visits and yet may still not be recognized. Most children with ASD, instead, experience a changing small square of perception that appears differently to each child as they focus on different areas of the face (Sasson, N. J. 2006). ABA therapist Jennifer Cuellar suggests that as each individual has very different needs, it is hard to generalize. For the most part, however, individuals affected by autism do experience a wide range of emotions; the difficulty lies in recognizing emotions in other people.

6. Technologies and Games to address autism needs

Research Question: How can sensory development and face and emotion recognition can be addressed via digital technologies, to create social and behavioral benefits for children with autism? What are the potential benefits to the child with autism and to the parents?

Figure 1 -Synchrony is a therapeutic music platform that helps parents and children with autism develop intimacy and promote understanding with each other through improvised music play.

(Tay 2015)

6.1 Web-based technologies

Research has shown that web-based technology may help isolated children communicate with others or “engage in activities” and can help address the psychological needs of many children with ASD (Bers, M.U., 2001). Marina Umarschi Bers created the “Zora system in 2001, a three-dimensional (3D) multi-user computer environment to help children who had undergone organ transplantation form virtual communities to share their experiences and combat the isolation created by their medical situations” (Bers, M.U., 2001). With this system, paediatric patients can build virtual rooms, share with others in real time through an avatar, and send messages or stories. By experiencing these activities in virtual communities, patients create a strong sense of “belonging and group identity” (Bers, M.U., 2001).

Research shows that patients found that the Zora system helped them find friends to communicate with and feel connected to the social world (Bers 2001). “They also responded positively to synchronous as well as asynchronous communication” (Bers 2001, 365-425) suggesting that internet technologies that create virtual communities present exceptional opportunities – especially for the children who feel isolated (Chin and

Tsuei 2014).

6.2 Puzzles and face recognition games

Research has shown that mobile tablets like the iPad help those with autism to communicate by using apps that include things like speech recognition (Tanaka, J.W., Schultz, R.T., 2010). Some tools have been created to assist children with autism to learn face recognition and emotions, including physical and digital puzzles like FaceStation games designed by the Center of Autism Research, Philadelphia (CAR); a game based on CAR's director Robert Schultz, Ph.D. and James Tanaka's, Ph.D. (University of Victoria) previous work (Tanaka, J.W., Schultz, R.T., 2010). At the University of Victoria, doctors developed the *Let's face It* (LFI) games series that is used to enhance intuitive discrimination of facial identities and facial expressions. *FacialStation*, on the other hand, was created to improve the therapeutic details of the previous series of games (LFI) with a more intense approach. FaceStation research includes *Face Puzzle Fighter, Face Invaders, Embed Faces, The Adventures of Pennsylvania Jones, Train Zoom, Dr. Face's Potion Shop*, and *Trex Trample* games (Tanaka, J.W., Schultz, R.T., 2010). CAR is currently (as of 2016) holding a study with children age group between 8-18 to measure the effects of Face Station games. After 12 weeks playing with the games, participants will undergo brain imaging before and after gaming periods to measure the effects of gameplay as well as an IQ test and other behavioural and social tests. The parents of participants will complete a questionnaire and undergo interviews to address the noticeable changes in their children as well. CAR believes FaceStation games enhances face recognition in children with ASD as well as improves their social skills (Tanaka, J.W., Schultz, R.T., 2010). Mobile devices show increasing development for use in schools, homes and in therapies. Although fast changing technology brings limited empirical support to these developments, there is still promise to the potential of these technologies. Since games on mobile devices have become less expensive and more ubiquitous, it is expected to create a trend in autism app creation, specifically (Kientz, J. A., Goodwin, M. S., Hayes, G. R., & Abowd, G. D. 2013).

6.3 Sensory Processing Approaches

Research indicates that over and under stimuli in sensory processing is one of the key issues experienced by many children with ASD, affecting children with autism and their parents. Out of this, I will build tools that address sensory issues to achieve learning in the recognition of faces and emotion. The research on digital solutions to face recognition demonstrates that tools for recognizing faces can potentially be very effective to autism interventions.

I thus propose to create an environment suitable for sensory processing before presenting a child with autism a context in which to learn in order to bring about better registered outcomes. For this, I have created two tools: the KOZA sensory chair and the FAERA app. These tools help resolve sensory processing issues by limiting sensory stimuli.

In the first stage, I focused on face recognition with the FAERA puzzle game app which was tested by John, a 6 years old child with high functioning autism. The results of John's play were recorded to show if the game-app successfully helps children to recognize faces and emotion. Seeing and completing a puzzle of the face of an individual from the life of a child with ASD, I propose, might effectively create flashbacks or repeated learning patterns in order to build a new, learned skill. The child might also overcome sensory issues with repetitive use of the app in therapies and develop feelings of comfort in recognizing family, friends' faces and emotions over the long term. In addition to the literature referenced that supports this approach, I acquired the expertise of Jennifer Cuellar, therapist at South Asian Autism Awareness Centre (SAAAC). Cuellar is an expert in ABA therapy (Applied Behavior Analysis), working with autistic children. She served as an advisor in identifying symptoms and during user testing stages of this research. Cuellar recommended non-standardized and non-clinical therapy methods as an approach to autism interventions. Non-standardized and non clinical therapy methods work well for understanding a child's mind. Furthermore, it has been shown that young children learn faster with digital tools. If we consider that children spend an increasing amount of time using screen-based technology, it can be surmised that they may learn faster using digital tools (Huber B., Tarasuik J., Antoniou M.N., Garrett C., Bowe S.J., Kaufman J., 2015). The inclusion of music in the app will explain and embed the emotion as many children with ASD show evidence that their receptiveness to music and rhythm is higher than other stimuli (Tay, 2015). The FAERA app is combined with an environment where the child feels most relaxed so she/he can observe the game carefully at her/his own pace and interact with it without distraction. There are many examples of the use of sensory mood rooms in earlier in autism research and for many other spectrums that need sensory development. These rooms create different sensory environments and serve many children with different needs at the same time. They generally include many sensory objects that are used to create stimuli in accordance with different levels and needs. Yet, these rooms are not easily accessible for daily practices, which is one of the reasons why I decided to create a chair that contains a small sensory environment with easy access for most children with autism. The KOZA chair is a sensory chair designed to support learning by preparing the test subject, John, a 6-year old child with high functioning ASD, for a playing and learning environment. As suggested earlier, research has shown that an autistic child's ability to learn is affected by sensory processing (Ayres, 1979; Dunn, 2001; Dunn & Donaldson, 2001), hence KOZA also acts as a small sensory processing cocoon. Most children with ASD fail to notice sensory input like being restless or seeking stimuli, yet they are often overly sensitive to sensory input and tend to withdraw from stimuli (N.B., Brown, Dunn, W., 2010). However, many children cannot learn if they are unable to respond because important pieces of information for learning are missing due to their unique sensory processing. This missing stimuli creates difficulties in receiving information and instruction. This is a critical situation that explains and proves that educators need the necessary tools to identify and design effective processes specific to a learning context (Bennet Brown, N., Dunn, W. 2010). Processes that create stimulating environments and embed learning into an environment, like using iPads or cocoon chairs in the classroom, direct a child to the sensory input periodically. This technique engages the child to relax and to complete the missing stimuli, facilitating the conditions for continued learning. Stimuli input recognition and sensory satisfaction is included in such an environment for most children to better learn and engage within. Cuellar, the autism therapist, was strongly supportive of my plan to implement face and emotion recognition training through a sensory environment that was extremely positive. She and the SAAAC Centre are hoping to use this research material, the chair and the app, for further observation and for interventions at the centre. As such, I moved forward with the idea as an acceptable as a therapy option, according to the therapists at the SAAAC.

7. Research Approach

7.1 Qualitative Research Approach

> "We inquire when we question; and we inquire when we seek for whatever will provide an answer to a question asked" (Dewey, 1938).
>
> Thinking is inquiry, questioning in a deep manner (Turnbull, N, 2004).

Qualitative research is used in this thesis; this is an approach based on a strong constructivist paradigm that posits that research-learning is active and develops an objective reality through observation and scientific study. My subject is John, a 6 years old child with high functioning autism and his parents who consented to this research project. John participated solely in user testing, where his needs in the areas of sensory stimuli and facial recognition led to the development of the FAERA app and KOZA chair. According to the therapist, these types of intervention based tools offer solutions to the needs of most children with ASD. With John and his parents as test subject, my goal as a researcher was to understand the rich and complex experiences of children with autism in order to develop solutions that can ease everyday life for themselves, their friends, and family in recognizing faces and emotions. Understanding what allows a child with ASD to relax and focus, I discovered, leads to better learning experiences and outcomes. I collected patterns of behaviours and responses in the child subject; specifically, I looked for signs where emotions were recognized, and how John responded to music when playing with the FAERA app game, when stimuli was controlled as he sat in the KOZA chair. I examined and analyzed John's behaviours searching for meaning, looking for the origins of needs and responses, and how to address them, ultimately creating an environment that responds to their unique needs. This project creates the conditions to affect the student/child-parent relationship by building better social communication skills.

8. Research Methods

8.1 Research Through Design

This thesis incorporated the qualitative research findings to develop the FAERA puzzle game and the KOZA chair. I employed a research through design (RtD) method that combines theory based design with empirical analysis. This method of using multiple steps leads the research through different stages of design, processing, and solution, in order to communicate therapies with positive responses (Chin and Tsuei 2014).

The application of the (RtD) method is mentioned for both the app and chair in the design process sections and in the following pages.

Similar to Tsuei and Chin studies already described, the FAERA puzzle app uses DGBL technology to facilitate therapeutic learning to address autism’s facial and emotional recognition problems. The FAERA puzzle game was created to be paired with the KOZA chair as part of an autism therapy intervention taking place in a controlled sensory environment. The KOZA chair takes learning with DGBL into a sensory environment, while simultaneously supporting DGBL itself. DGBL Technologies are very important tools in Human Computer Interaction (HCI). Design-oriented research in HCI design leads the researcher to observe, collect data, identify and focus on an individual’s social connections and expressions, and to develop surprising discoveries through the prototyping process. Active testing and continued development create data for collection and classification (Chin, J.C., Tsuei M. 2014). As noted earlier, my research was conducted with Applied Behaviour Analysis (ABA) therapist Jennifer Cuellar at the SAAC. Her insights into my research helped direct the design process for both the FAERA app and the KOZA chair, the development of the processes of facial- and emotion-recognition and the creation of a suitable sensory environment.

9. Prototyping Stages

My process of research through design (RtD) consists of three prototyping stages. First is the FAERA app design, second is the KOZA chair and its sensory engagement with the child, and the third concerns the activity of LED lights and their connection to the child's sensory process.

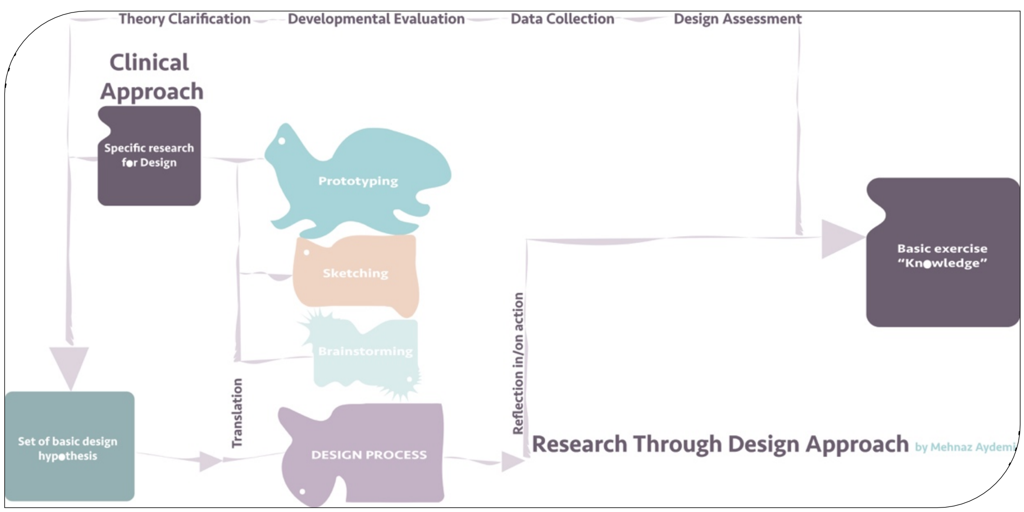


Figure 2- Research Through Design Process(RtD) (Delle Monache, S., & Rocchesso, D. 2014)., Aydemir,M., 2015

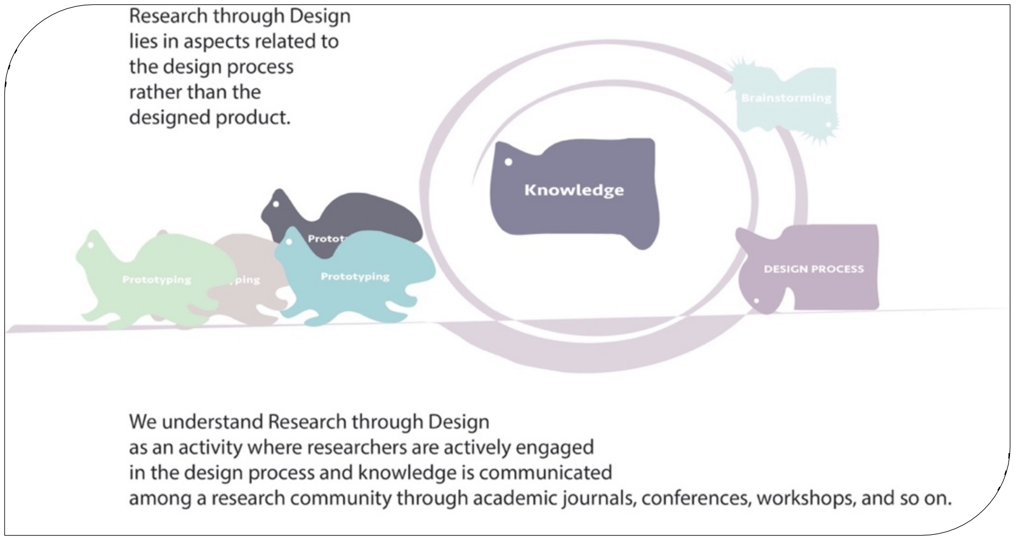


Figure 2-1 Research Through Design Process(RtD) (Delle Monache, S., & Rocchesso, D. 2014)., Aydemir,M., 2015

1. The process of RtD starts with a basic design hypothesis, as shown on Figure 2 (Delle Monache, S., & Rocchesso, D. 2014). My research question is: H**ow can sensory development and facial and emotional recognition be performed together in order to observe social and behavioural benefits for most children with autism? Additionally, what are the potential benefits to the child with autism as well as the parents?**

2. After the first step, RtD follows a transition process that uses brainstorming for ideas, sketching and prototyping techniques. The process then includes reflections, leading to the collection of data and knowledge for further development. This stage helps to bridge a subjective research question into more objective findings.

3. The next step was communicating knowledge by discussing my plans with the therapist, referencing academic papers and research of previous findings such as the proven concept of how sensory satisfaction creates a greater learning of context (Dunn, W., 1997).

Utilizing this research in facial and emotional recognition and sensory processing, I was able to synthesize a plan to enhance learning for subjects that involve face and emotion recognition and sensory needs. I synthesized a 9-piece puzzle app where personalized photos of people in the child’s life can be uploaded and used. In addition, I created the environment where his (John’s) sensory needs are met. Having both developments under the same roof allowed me to synthesize a method through which to improve face and emotion recognition using a sensory chair environment. The FAERA app and the KOZA chair were initially specifically designed for John in accordance with his sensory issues and needs that are described in the interview process found in the following chapters. I will discuss the process of integration in the following section.

10. Research in Face and Emotion Recognition and Sensory Development

10.1 Background

In order to address facial and emotion recognition, the FAERA puzzle game is designed as a tool that, upon completion, offers rewarding music identifiable with an emotion. This will boost the child's enthusiasm and successful use of iPads for his development. Earlier hard copy examples of similar puzzle games were created and used by therapists for many years, with few examples of digital support therapies. MRI evidence confirms that differentiated activation in brain regions shows missing neurocognitive functions in those affected by autism, including gaze processing, facial recognition, emotion expressions, and other tendencies (described earlier) (Golarai, G., Grill-Spector, K., & Reiss, A. L. 2006). When an individual's sensory system can coordinate incoming information properly, the child is more likely to elicit an efficient response that will minimize stress by resolving issues that arise in their life. The child will have less stress once the stimuli is in progress and can move to the next step in his/her life (Berger, D.S., 2002). Stimuli satisfaction will impact the child's social communication and behavior positively as it is explained in Dunn's model of sensory processing. Dunn's model of sensory processing is based in neuroscience and behavioural science, and explains how sensory processing affects a child’s behavior. In 1943, Kanner described how sensory results show that certain behaviours provide endless joy, like staring at a flickering light, as well as heightened sensitivities that caused distress like a covering of the ears to certain sounds, in most children with autism (Kanner,L., 1943). These experiences are considered in the Sensory Experiences Questionnaire (SEQ). The SEQ – formerly known as the Sensory Supplement Questionnaire – is a brief (10-minute) caregiver report instrument that was designed to evaluate behavioural responses to everyday sensory experiences in children ages 5 months through 6 years. Its primary purpose is to identify sensory features in young children with autism, and to find patterns of hypo- and hyper-responsiveness among those with autism. I used this method on my parent interviews to identify John’s sensory experiences and his responsiveness.

Another approach to sensory stimuli involves musical therapy where rhythm and patterns in music are used to affect the brain’s responses in sensory integration in those with autism. Music therapy research suggests that the brain’s auditory system is the key to quick and automatic responses as music stimulates “the limbic system’s release of emotions and moods” (Berger, D.S.,2002). Rhythm can be used anywhere in therapy, and in music sensory therapies studies show that if movements and words are completed using rhythm, it has developmental benefits in Autism. Patterns that appear in rhythmic forms in language can embellish and drive the excitement of an upcoming beat.

Patterns play a big role in sensory therapy for most autistic children (Berger, 2002). Specifically, many children with autism respond to rhythmic sounds better than those found in regular music. If you ask a child with autism to walk from one corner of the room to the other, from a distance she/he may not hear or respond directly. Yet, when accompanied by a rhythmic music’s tempo, John then followed instantly. This research suggests that the inclusion of music in therapy may increase the comprehension of emotions for the child along with the FAERA puzzle game in sensory environment.

Music therapy plays a very important role in autism’s sensory interpretation as it provides repetitive stimuli that helps the brain to respond with patterns in other learnings (Berber, D.S., 2002). Music and images contain strong patterns for learning behaviours in autism (Berber, D.S., 2002). These patterns can be used in practices of sensory development and facial and emotion recognition, including musical patterns and repetitive patterns like puzzles, in order to help children with autism to develop systematic behaviours. Behaviours can then be transferred to systematic social communication and future development. I used the same approach in my research with music and images as identifiers of key subjects to support emotion recognition on the faces shown in-game once successfully completed.

11. Target Users & Everyday Use

The current prototype stage of FAERA and KOZA have been designed to accommodate and adjust to the different learning and sensing needs of children on the autism spectrum. For example, the chair cushion can be adapted to different textures and used with different learning apps.

The child (end user/ user tester/participant): Users for the app will be children in the age group of 6 to 11 years that are on the autistic spectrum. The child will interact with the app after approaching the chair. The child will sit and a lap pad will be attached to the chair by the parent or therapist who will also be directed to select and load the photos of people known to the child. The therapist or parent(s) should observe while the child plays with the app in the chair environment. When the child and parent are more familiar with system and environment, their experience should allow the child to select photos if applicable. A therapist may also observe the process and make suggestions regarding the way the game is played, as part of a directive play therapy, or the difficulty level based on age group. If the child needs directions or experiences frustration, the therapist or parent may either end the game or encourage the child to continue, depending on the situation.

12. Development of the FAERA (Face & Emotion Recognition App)

12.1 Description

I asked three questions regarding affordances that should be considered in the development of the project: The first question is: what are the designed concepts that will create the foundation of the project; second, how can it be transferred to learning, and; third, what is the specific content that best provides learning context to children with autism? We can see them as follows, below.

We know that building visual performance skills, puzzle making is a fun activity. The key factor in this design that will help with emotional recognition is that a photo of an emotion is easier to process than a live face full of micro gestures. ABA therapist Jennifer Cuellar explains that she often uses flashcards to teach emotion before moving on to live people. One strategy commonly used in ABA therapy is to pair a challenging task with an easy and fun task to reinforce a positive association with the difficult task. This way the student is more likely to want to engage in the difficult task. Cuellar adds that she always needs the student to be motivated to learn. That said, not all individuals with autism excel at puzzles. Many do, but Cuellar says that she also met many students who are on the lower end of the spectrum that cannot do puzzles at all.

So the first designed concept was the puzzle game being integrated to emotion recognition by using music at the end. The FAERA app is designed to be used in conjunction with the sensory chair KOZA. The design of the FAERA app enhance face and emotion recognition while the KOZA chair boosts sensory development. (Gringras, P. and Green, D. and Wright, B. and Rush, C. and Sparrowhawk, M. and Pratt, K. and Allgar, V. and Hooke, N. andMoore, D. and Zaiwalla, Z. and Wiggs, L. 2014). The user scenario was imagined as follows. First, the app will be uploaded with images and related music. The uploaded photo is divided into 9 pieces by the app, creating a puzzle. Interaction in the FAERA puzzle app uses drag-and-drop – found on most tablets – for easy and intuitive manipulation. Once the child completes the puzzle, s/he will see the emotion shown on the completed face of the photo and hear music to accompany the emotion on display. Upon completion, the child sees the following message: “If a person is smiling it means they are happy; when I hear music that makes me dance, it means I am happy.” The child then can see the smile and repeat the word happy with therapist’s support and can start building a learned skill for a happy face. The FAERA app will relay the information that the child has completed the game successfully, to the KOZA chair using an Arduino circuit board via Bluetooth. After receiving the information from the completed game, the KOZA chair gives feedback in the form of flashing LED lights; this represents a reward for the user.

The role of the chair is to prepare the child for a relaxed, comfortable playing and learning environment, offering positive stimuli, according to the specific child’s need. The cushion texture inside the chair, the sequence of LED strip lights, also the puzzle difficulty are components which can be altered to meet each child’s specific needs. The KOZA chair serves as the first step into development in this research as it is built to satisfy the necessary sensory need for the child to engage with the game/

puzzle enthusiastically. For sensory stimuli, the KOZA chair uses pillows with various textures that can be arranged and bring child to comfort before she/he starts to play the game.

The iPad is built onto a weighted lap-pad that is strapped to the chair with Velcro closures to help the child sit still and focus on playing. The concept of weighting the lap pad is taken from sleep studies in autism where weighted blankets are used for some with autism. Although the research shows no effect of weighted blankets on sleep patterns, it is still a favorite choice of parents and children with autism for its soothing reasons (Gringras, P. and Green, D. and Wright, B. and Rush, C. and Sparrowhawk, M. and Pratt, K. and Allgar, V. and Hooke, N. andMoore, D. and Zaiwalla, Z. and Wiggs, L. 2014). Once the child has completed the facial puzzle, s/he can try to recognize and name the emotion by the help of the therapist; through reminders and repetition, the child can start build a connection between the emotion and the face gestures. These connections will occur over the long term, as the child becomes better able to identify people and their emotions in her/his life through practicing with the app. Cuellar plans to test this app at the center in the future, working to understand whether practicing facial and emotional recognition with

Applied Behavior Analysis improves learning context development in children. Also she hopes that show that teaching through repetition and rewarding correct responses can achieve positive results in autism interventions (Cuellar, J., ABA therapist SAAAC, 2016).

12.2 Prototyping Process

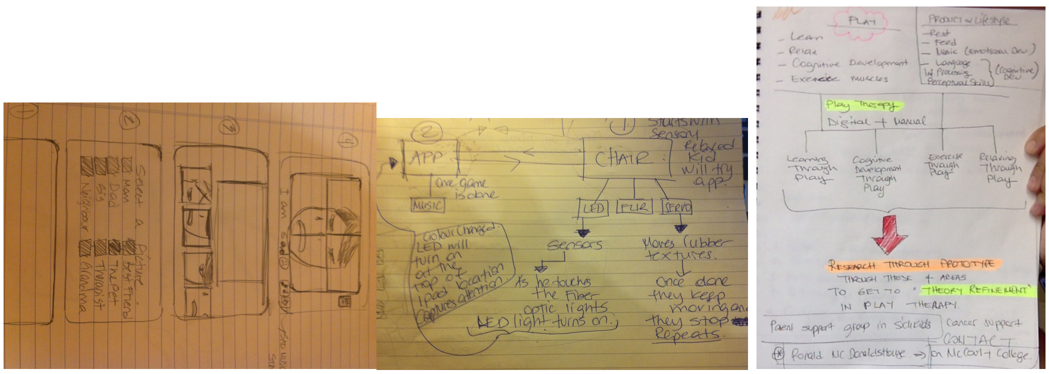


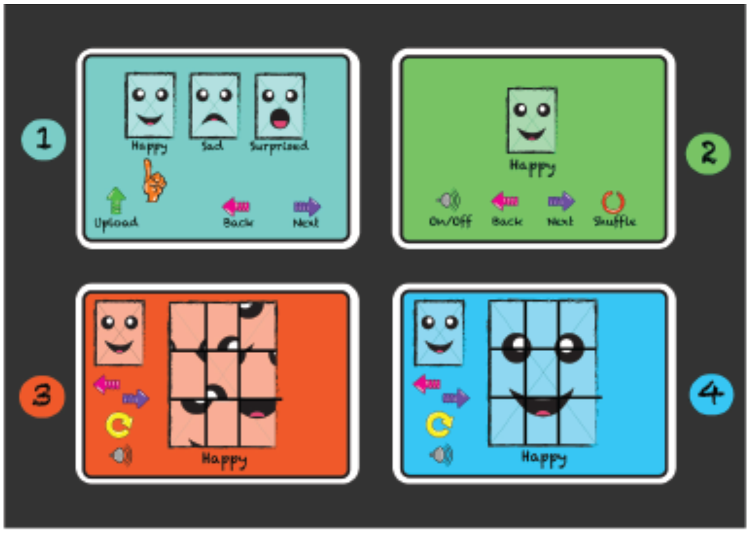
Figure 3 - Early sketches of the puzzle app

Figure 4 - Prototype Stage #1

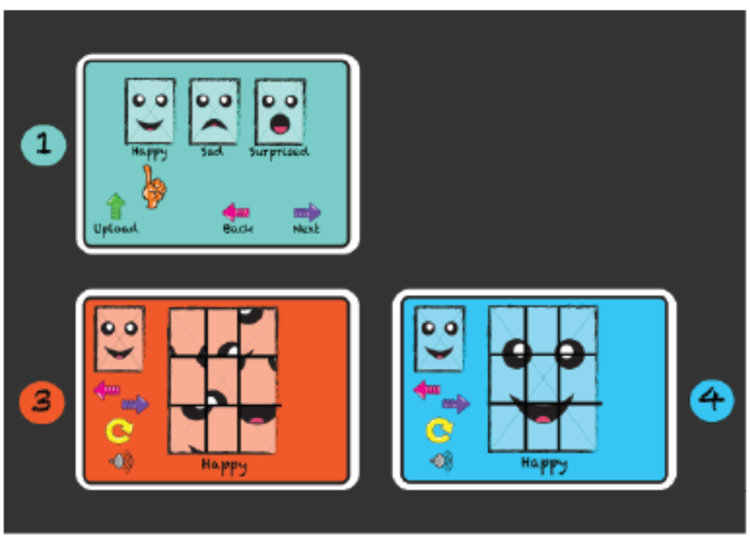
i. The code: FAERA app is created by using Java Script, HTML and CSS. The process of creating a puzzle app started by using an open source code written in Java Script. I developed the app to make it suitable for the age group of 6-11 years old children. I started with a 12-piece puzzle game then adjusted the difficulty level, adjusting the number of pieces based on age as suggested by Cuellar. The level of difficulty can be adjusted in the code in accordance with the user's age, needs, or to suit specific therapeutic goals in future research.

Figure 5 Prototype Stage 1

ii. : The FAERA app is designed to be a simple and intuitive user interface for children with ASD. At the end of the development the design resulted in a simple 2-page puzzle game with necessary indicators for the user, such as a pink arrow, reset button, and button to upload and access images. The images and music may be uploaded from existing files or taken using the iPad camera. Cuellar (SAAAC, 2016), suggested that a 9-piece puzzle is suitable for children with autism between the ages of 6-11. Music was chosen for the app based on research demonstrating that favorable music creates feelings of happiness, sadness and surprise; these visuals will be on faces in the app. User testing showed that the song *Bear Cha Cha Cha* (Lurye, P., 1998) was chosen as a favorite happy song by 2 children with ASD who were between 6-11 years old. (in the page https://www.youtube.com/watch?v=VzVSVNy-j98). Furthermore, the children showed interest in this musical selection by repeatedly asking for it to be played again.



Early prototype shows 4 steps on the app which was not necessary for a simple puzzle game.

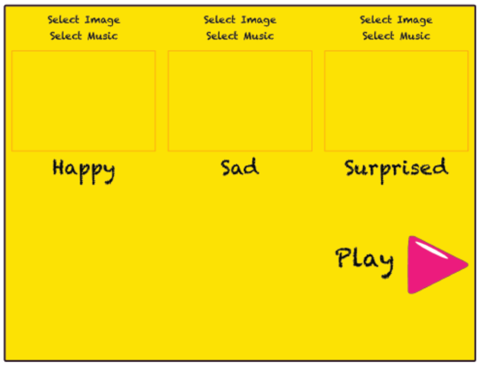


Page #2 was eliminated to simplify the user interface then page #3 was eliminated for a simpler version.

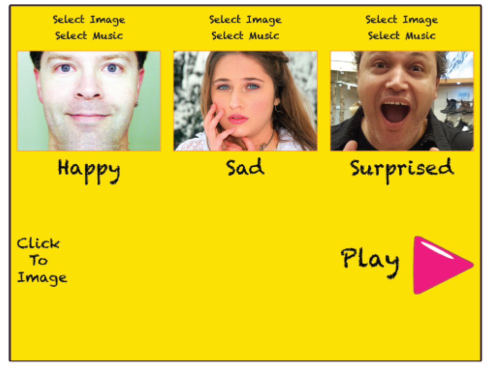
Figure 6 Early Prototype Stage 2

Figure 7- Splash Page - Click to start the game

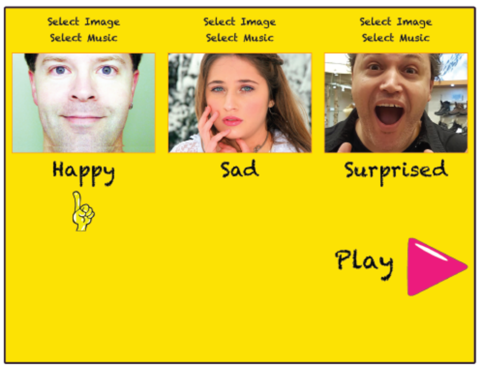
iii. The last stage of the prototyping involved creating the 2-page game app with a splash page that contains the logo of the FAERA app. The user interface was designed as simply as possible so as not to overwhelm the child with ASD, instead allowing them to start playing the game immediately. The game starts by touching the logo on the splash page. 3 emotions are selected for this specific game, happy, sad and surprised, as these are the most common needed areas for most children with ASD to identify (Castelli, F. 2005).



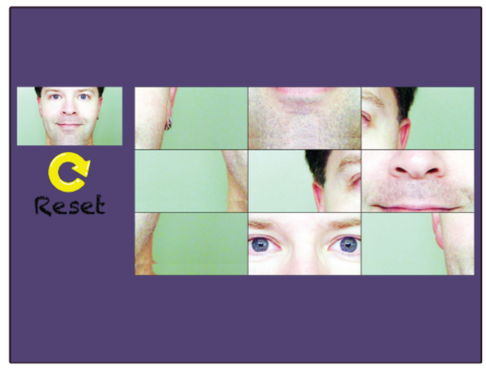
STEP 1- Select Image and music to upload from photo and music library



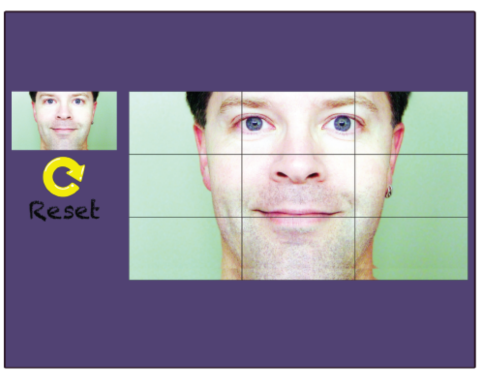
STEP 2- Click to image to upload the game, pink arrow will shake once image is uploaded



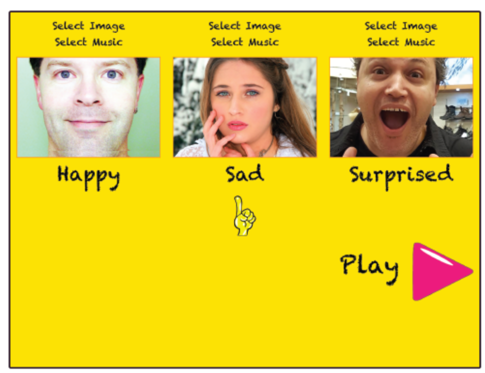
STEP 3- Click pink arrow to shuffle image on next page



STEP 4- Play the game



STEP 5- Listen music once the game is completed successfully, then reset game



STEP 6- Upload next image

Figure 7a - Final Prototype

Gameplay follows the steps shown on Figure 7. Once the game is completed successfully, music related to the emotion will start playing on the last page.

iv. The LED strip starts flashing in the KOZA chair as a reward after the game is successfully finished.

12.3 Reflection

I developed the game for a specific child, John, who participated in the user testing as mentioned in the qualitative research section of this thesis. He is very interested in iPad games and mostly enjoys race car games, action games and reading with his therapist using iPad apps. John was seen by the therapist as enjoying the FAERA app very much.

The initial application prototype was developed and playable on a laptop computer instead of a tablet as intended. Even so, John went through the first step and managed to drag puzzle pieces in the game and completed the picture with the guidance of the therapist. The laptop format required too much effort, as it was difficult for him to use the trackpad to press and drag at the same time, in order to drag the puzzle pieces around the game. Because of this observation, I transferred the game to the iPad and his ability of completing the game was much faster. On the tablet, John completed the game in under 2 minutes. As he completed the happy face puzzle game and heard the happy *Bear Cha Cha Cha* music, John started smiling and laughing. Excited, he answered with word "happy" when the therapist asked if the man on the picture is happy. The therapist commented that two minutes was a good amount of time to complete the game for his age and the difficulty level of the puzzle. In this situation, I was told by the therapist that most children with autism learn by repeating what they hear. As such, John's answer may have been an answer that simply was based on hearing and repeating the word "happy" in the question. ABA therapists mention that many children with ASD do learn in long term by the help of these repetitive answers. I am hoping that repetition of interventions in their routine therapies will start creating measurable result in face and emotion recognition in the long term.

13. KOZA The Sensory Chair

13.1 Description

Most children with autism have many needs to be addressed in terms of having to do particular actions at a particular time. The effort of trying to get a child with ASD to sit down, to eat, or to go to sleep requires much more effort than that spent with a neuro-typical child. It is often reported that most children with autism have very little understanding of their own mind, or those of others, when it comes to expected behaviors (Frith, U., & Happe, F. 1999). As a result, mostly an ASD child is unable to know that he is expected to sit down on a chair and start playing with a game on an iPad without an actuator element or explicit direction. For these reasons, I sought to develop a sensory environment in the form of a chair to encourage learning.

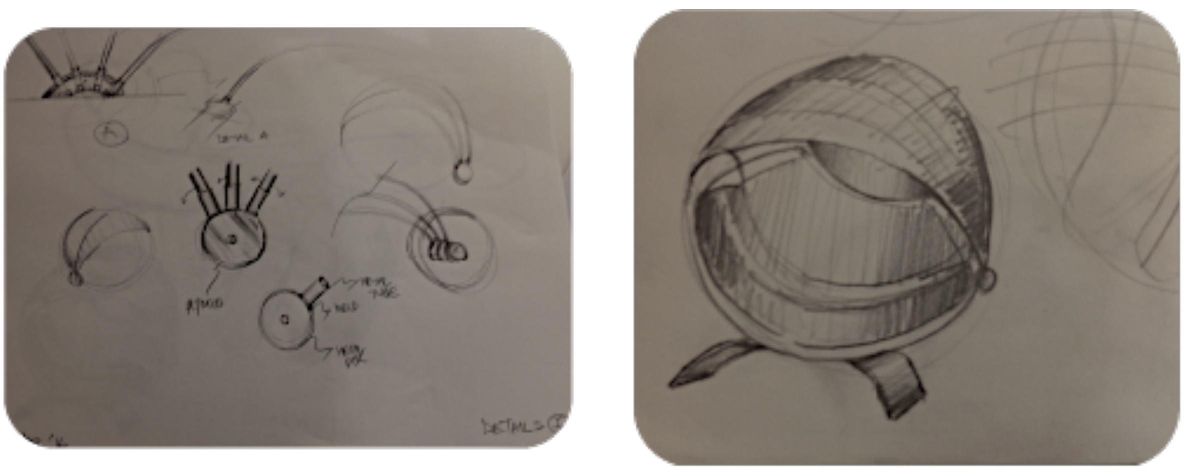


Figure 8 - Early brainstorming for the sensory objects

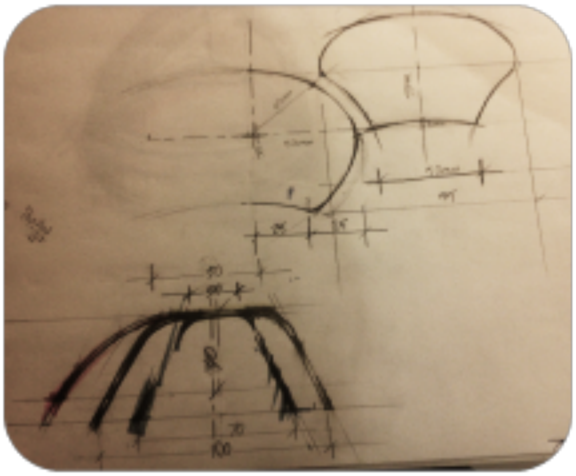


Figure 9 - Early brainstorming for the sensory chair

The KOZA chair will be a sensory environment for children with mid and high functioning ASD. Cuellar suggested that the KOZA chair might be attempted in therapies with low functioning children with ASD but is less likely to be successful for their therapy (2016).

13.2 Prototyping Process

i. Paper Prototyping

Paper prototyping was the very first approach I employed to understand the design and needs of the chair, where the main concerns were;

a. To be able to engage the child
b. To be able to create a cocoon-like enclosure making a secluded sensory environment

c. To make a chair that could be connected to digital components

d. To create a comfortable and desirable chair with sensory objects for the child to use with excitement and benefit from digital feedback.

Paper prototyping helps a great deal in understanding the concept, creating a manufacturing technique and selecting materials. I created a series of paper prototypes for the KOZA chair to focus on correct ergonomics as a lowered height and a larger lounging / sitting are, and to create a product that is as functional as possible to later implement digital components.

Once the child is near the chair and close enough to sit down, the proximity sensor actuates NeoPixel LED ring lights installed on each sides of chair’s side that will light up as slow pulsing lights. The lights encourage the child to sit down in the chair and play with the app. The sensor has a high range capacity so it response to the movement even from a wide angle. Once the game is successfully completed and the app starts playing music, the LED strip lights will start flashing inside the chair on the the felt hood. The lights were located to be noticed from any angle regardless of the direction from which the child approaches. Light also can be placed in different locations if needed. They were located strategically for visual benefits and also for the child to notice them as an invitation to the chair.

ii. Finding the right form and materials

Figure 10 – First 3D FDM model

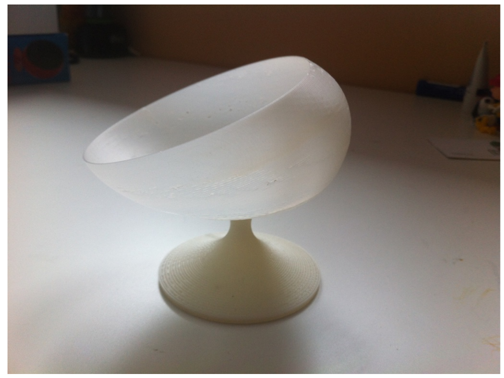


Figure 11- First 3D FDM model

The KOZA chair was first conceptualized while I was thinking of a 1960s bubble / egg chair design in order to create a cocoon-like environment for the chair. For the future, a plastic model of the chair would allow for the potential to mass production and tooling for possibility to produce for more quantity.

The first chair prototype was created in a CAD environment using SolidWorks software and getting a 3D fuse deposition modeling (FDM) model done in PLA (polylactide) as shown on Figures 9 and 10. To create a cocoon chair, I thought about a closure that could cover the top of the chair to create a secluded environment for the autistic child. Children with ASD need to isolate themselves for long periods of time as part of their sensory needs. The closed-top chair idea was designed to meet the need for isolation. Most adults with ASD report that having a closed, tight space nearby, such as a closet, cocoon chair, or sandwich-like chairs where one can sit tightly between two matresses, relaxes and and helps control feelings. A sense of being in control relaxes most people with ASD. The predictability of the space also gives the child a sense of controlling their own environment. If children with ASD are satisfied with their environment, they feel emotional security thereby raising their sense of control (Sherrod & Cohen, 1978). I am aiming to help users to control their choices, to build their ability to communicate with the neuro-typical world. Manufacturing a plastic bubble chair, especially creating a mold, was a very challenging and expensive endeavour. As such, I decided to create a second less expensive prototype.

I designed the chair with a tribute to Charles Eames' Molded Lounge Chair (1946) which is considered one of the most comfortable and best chair designs of the 20th century. Combining two parts of bent flex board with two layers of cherry veneer is a fast and affordable version of manufacturing a veneer chair.

Figure 12 – Foam-board model, brainstorming

iii. Previous Developments

Figure 13 - Eames' Molded Lounge Chair (1946)

CRADLE is a sustainable rocking chair created by a team of researchers at Victoria University of Wellington

Figure 14 – Cradle Chair – by Richard Clarkson

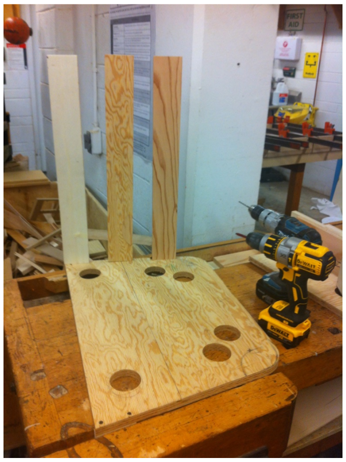
Tactile disks help children with ASD to relax their sense of touch around the hands and feet

Figure 15 - Occupational Therapy tactile disks by The Sensory University

Figure 16 - Paper Prototype

Figure 17 - Paper Prototype

After creating the last prototype as shown on Figure #17, I decided to design a plywood chair with a hood closure that is made entirely out of felt. I chose wood and felt materials because of their natural look and feel. As Eames' curvy plywood chair symbolizes a form of organic architecture, I wanted to point out the thinking power of an autistic mind through freehand wood bending and natural, simple material choices. Thinking power stands metamorphic ally for the free flow of the autistic mind as flawless curves seen on the chair structure.



Creating the mold

for the chair seat

Figure 18 - Molding

Figure 19 – Wood Mold

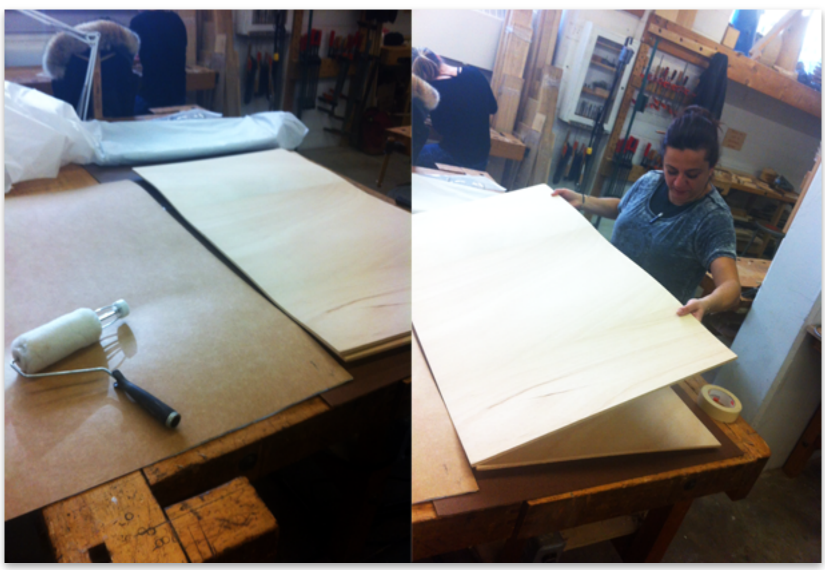


Figure 20 – Laying 4 layers of material to glue and vacuum in a bag

Figure 21- Finishing the seat

Figure 22 – Clamping on mold

Figure 23 - Seat & back

Figure 24 - Seat & back & base

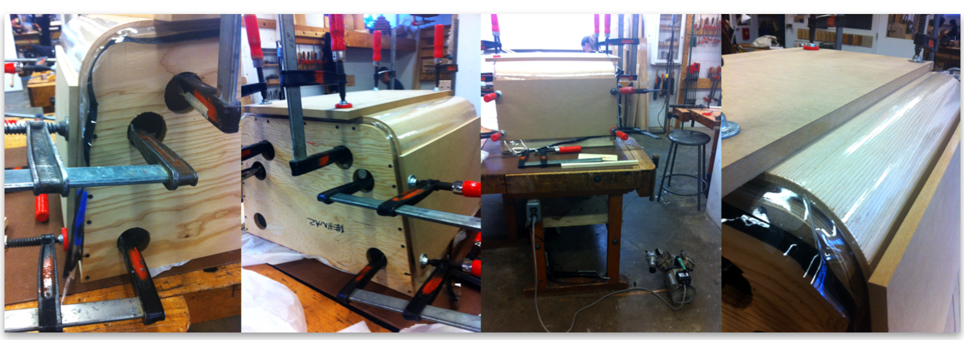


Figure 25 - Bending flex board on the mold and clamping to position it.

Figure 26 - Air suction

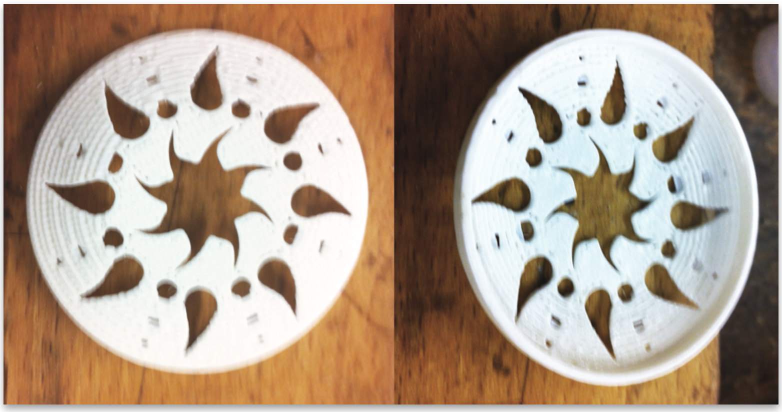


Figure 27 - 3D printed caps to cover Neopixel LED ring lights

Figure 27-1 - LED ring location on the seat

iv. KOZA Chair details

The KOZA chair I designed has two different colour felt covers, yellow and purple, that the child can open and close to enter. The felt hood is attached with pin and bolts on the pivot points of both sides of the chair. The colour choices were suggested by the therapist as many children with ASD prefer solid vivid colours. The hood provides a feeling of nested security that most children with ASD need. It also serves as a dome where the reflection of LED light can successfully be implemented for calming. An LED lighting strip is attached on the inner edge of the chair hood and provide the digital feedback at the end of the successfully completed puzzle game, by flashing gently as a reward (Sherrod & Cohen, 1978). Also therapists at SAAAC agreed that children would like an option of closing the hood of the chair for quiet play. The KOZA chair contains very detailed construction with three elements: wood, felt hoods, and LED lights. The felt hoods are stiffened by applying white glue with a brush as it is used in traditional hat making techniques. I had to try different mixtures to make sure the end result is a felt that is stiff enough to bend as plastic and yet does not feel wobbly once installed. It was critical to create a functional open/close feature for the child to easily operate the hood.

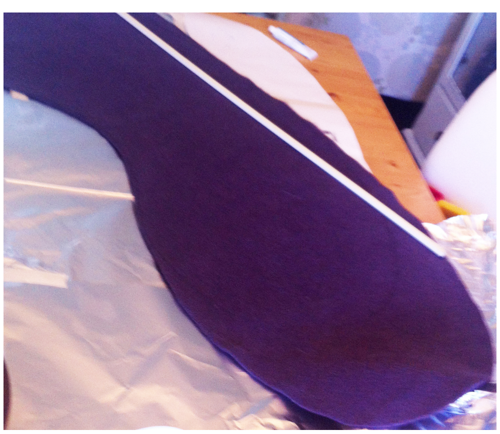


Figure 28 - Felt 1 front hood

Figure 29 - Felt 2 back hood

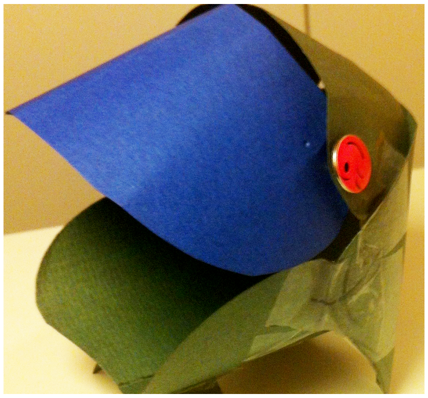


Figure 30 - Paper prototype shows the placement of felt hood

v. Applying digital components to the KOZA chair for digital feedback

Adafruit NeoPixel Ring - 16 x 5050 RGB LED

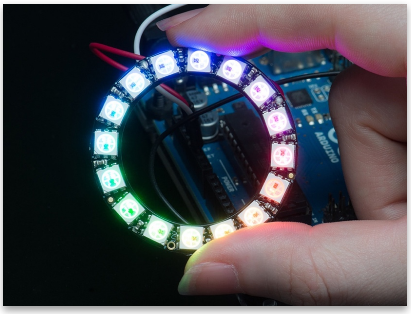


Figure 31 - NeoPixel LED lights-Adafruit Figure#32 - Strip LED lights-Adafruit

I decided to use NeoPixel LED lights for the KOZA chair to give digital feedback. Two different types of lights were used in this project. One is a NeoPixel Ring - 16x5050 RGB LED with integrated drivers. This type of LED lights come in 12, 16, or 24 addressable RGB LED lights in different sizes. These are chainable rings that come with very bright controllable color options. I used two rings for the side of the KOZA chair that are actuated by a proximity sensor. Once the sensor is activated upon approaching a certain distance, the rings start pulsing yellow and purple lights. This is used to trigger the child's curiosity and to invite them to sit down and explore the game. NeoPixel rings are mounted on both sides of the chair seat and connected to an Arduino micro-controller through holes in the bottom of the seat. The caps are used to cover the NeoPixel ring LEDs that are shown on Figure 27. They are used to diffuse a soft magical light to invite children to sit on the chair and experience the game.

Figure 33 - NeoPixel LED lights connected to an Arduino micro-controller

vi. MB1010LV-MaxSonar®-EZ1™High Performance Ultrasonic Rangefinder

I used an MB1010 LV-MaxSonar®-EZ1™ High Performance Ultrasonic Rangefinder sensor to measure the distance of the child from the chair.

The sensor is located at the front of the seat back, and is connected to the Arduino micro-controller and to the NeoPixel rings. The child can approach from sides or front of the chair to recognize the lights.

While manufacturing the chair, there was a major crack on the veneer material because of excessive bending that was fixed with an additional application of veneer.

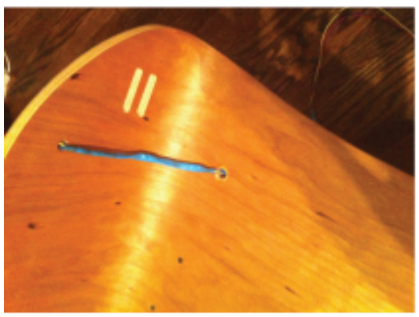
Figure 34 – First assembled prototype

The KOZA chair contains very detailed construction with three elements: wood, felt hoods, and LED lights. The felt hoods are stiffened by applying white glue with a brush as it is used in traditional hat making techniques. I had to try different mixtures to make sure the end result is a felt that is stiff enough to bend as plastic and yet does not feel wobbly once installed. It was critical to create a functional open/close feature for the child to easily operate the hood.

Sensor installation

NeoPixel ring closure

Securing iPad to the chair



Instaling NeoPixel rings

Figure 35 – Installation details

vii. Technical Connection

Adafruit NeoPixel Digital RGB LED Strip - White 30 LED - WHITE

NeoPixel strip LED lights also come in different lengths and light counts. I selected the 1-meter length strip that houses 30 lights— an amount and length determined by the hood size. The LED strip is attached to an Arduino as NeoPixel rings yet work independently using a Bluetooth connection that links the iPad app and the Arduino micro controller. After the successful completion of the game and the music playing, the app sends data to the LED strip via the Arduino through a Bluetooth connection through the computer, causing the lights to start flashing immediately. The sequence and brightness of the lights are adjustable depending on the child’s sensibility levels. For now, the brightness is set to 25, with the LED having a slow flashing action in accordance with John’s needs. The connection of the LED strip to the chair is done through the felt hood and side of the chair with the cable hidden under the seat where all of the components are housed. For this prototype I used a private network created through a router in order to create connection between the iPad and the server to turn on LED strip lights at the end of the game. Although it is a safe connection, Bluetooth connection is simpler technology for users to set up the chair and use on daily basis.

13.3 Reflection

The KOZA chair intended to support the face and emotion recognition therapy concept in a personal sensory environment. The chair needed to be large enough to act like a sensory room environment, yet also compact and safe enough to handle the child’s needs and satisfaction. Comments from therapists were taken into consideration while creating the design concept, ultimately creating a result of sensory satisfaction that suits my research aims.

On one hand, there were obstacles as a result of not testing the structure earlier. For example, I discovered a last minute issue concerning the need for a component shelf to house Arduino board and cables; this need meant I needed to alter the existing aesthetic appearance on the chair leg. Although the shelf is necessary, earlier consideration would have led to a more pleasing leg appearance.

The chair, however, is described as playful and receives excellent feedback from the therapist in terms of design and functionality. User testing will follow in more detail in the future as there was not enough time to transfer the chair to SAAAC for John to test. Complete user testing is performed successfully at the SAAAC. The SAAAC center would like to keep the KOZA chair and FAERA app to include the program to their 2017 therapy intervention studies. I am happy with the final design.

14. Conclusion

This project is meant to help autistic kids to live in a world where they will experience biases expecting them to conform to neuro-typical behaviors, including recognizing and responding to mood. As autism exists on a spectrum, it would not be right to address and generalize autism as a disorder. It is my hope that this chair and app will help kids on the spectrum to develop skills for better communications in the society.

New therapeutic approaches to facial and emotion recognition, stimulating the sensory processing of children with autism, is a promising new area that appears to aid learning in autistic kids. My design concept reflected research showing learning needs of kids with autism, and creates a new research area that hopefully will be developed further and will serve as new future therapy. As shown, the support of various types of digital technologies for children with autism can be extremely beneficial; they can aid issues faster and create better measurable results for developing routine therapies. (Adrien et al., 1987, 1992, 1993; Baranek, 1999; Dahlgren & Gillberg, 1989; Kientz & Dunn, 1997; Ornitz, 1989; Ornitz et al., 1993; Osterling & Dawson, 1994). To understand these needs, I examined research studies by therapists, philosophers, digital technologists and designers, as well as parents who are the most important way finders, and also undertook user testing reflections through RtD method. I have come to the conclusion that digital technology can help in autism research by employing therapy tools to engage these kids in social communication, via cleverly designed products.

Since the needs of every child are unique, there is no 'one size fits all' when it comes to autism therapies. This thesis clearly shows that it is critical to consider the design of every element in order to create the best possible learning environment for kids with ASD. Everything from the selection of the fabric used in the cushions to the level of brightness and sequence of lights, to the simplicity of the app was considered specifically to be modifiable to each child's unique needs.

The KOZA chair is customizable and can also serve just as a fun tool if learning is not considered. Also the FAERA app is only one example to be offered to children with autism. I believe that future therapies in autism will bring family input and child's choice more into consideration, as we need new research in the area, so that we do not implement the same forced interventions to all. The KOZA chair and FAERA app will be used for an intervention by the SAAC in their 2017 program, according to by

ABA therapist Jennifer Cuellar. I will get test results and feedback for the next design phase. This thesis successfully generated a new area of research and potential for new methods of therapy that has interested therapists and parents greatly.

Jennifer Cuellar' (2016), the therapist, comments on this project, stating: "As it is a very promising concept in face and emotion recognition, we are excited to include the project to our program" at the SAAAC South Asian Autism Awareness Center. She also mentions that the project using the face and emotion recognition app in sensory environment may help children to become calm enough to apply play therapy techniques and hopefully will get them to more quickly and effectively learn the emotion of others to engage in a learning context in other studies, and to be able to communicate with their families and peers.

15. Suggestions for Future Research

The Studies and examples cited in this thesis demonstrate how much progress has been made in facial and emotional recognition in kids with ASD. Ultimately, it is up to society as a whole to create greater empathy and accessibility for people who live with autism, and to not rely on kids to accommodate typical communication patterns such as mood recognition. However, many individuals with ASD do seek out tools to help them to learn or adapt to common (neuro-typical) communication practices. The most important suggestion for future research, I believe, is to continue to develop individual studies in therapies for autism, since every child has unique problems that need to be observed and addressed individually. Shifting to individualized therapies and tools may serve in-home settings or awareness centers for more compact, serving as on point therapies. Tools like apps or physical development materials for autism can be developed with especially parents' inputs and suggestions, to assist the development of product design strategies and to leverage the advantages of digital technologies. Scientific input, as found by research and studies, should follow product development for the benefit of fast growing technology in the development of autism therapies. As well, interaction and industrial design should be incorporated in autism therapy research to develop new therapeutic products, services, and methods. The combination of technology and design in the realm of therapeutic products is currently all too rare. This is a shame as autism tool design is a space of opportunity, and we are in dire need of well-designed, ergonomic and well functioning products for kids with ASD. Finally, collaborative work between designers, technologists, therapists and parents, and people with autism would help to raise awareness and create more functional and useful product development using digital technologies in autism research.

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Appendix A

User Testing

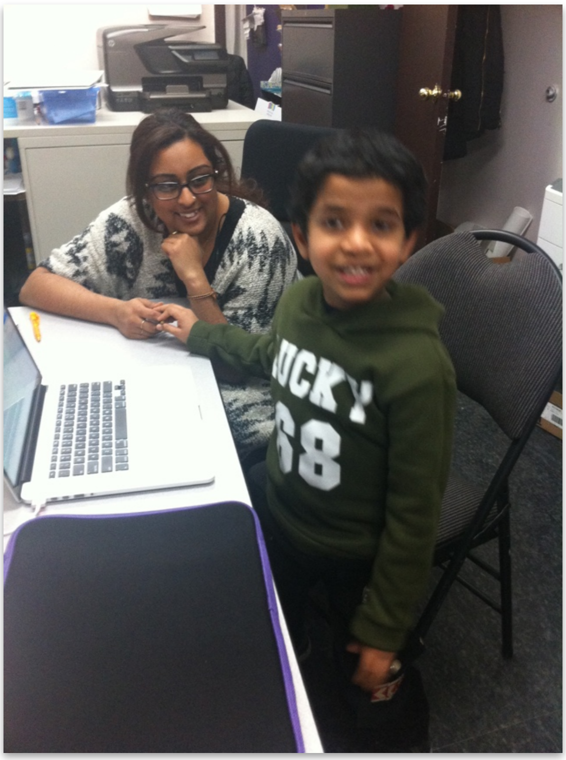

Figure #34 – John with his therapist trying the FAERA app

ABA Therapist Jennifer Cuellar's Observations and Suggestions for Face & Emotion Recognition Therapy with the FAERA app:

There is a video recording of how John was playing with the app on the computer. Also his reactions at the end the significant difficulty with his recognition of face and emotions. We asked questions about what the person on the picture is doing and he couldn't identify the happy feeling. As we said that he is happy, John repeated as happy. And future recordings show how he reacts to iPad implementation of the game and the music as well. He was happy and surprised to hear the music at the end. He smiled with the music. There are not really any specific textures that bothers John. He is not particularly sensitive to tactile sensory factors except unfinished wood surfaces.

- John's favorite activity is basketball. If ever he is distressed his parents use basketball as a way of stress relief.
- John cannot identify emotions by looking at a facial expression. So this will be a future goal for him. When you ask how is this person feeling? He may not respond...but when you ask if this person is happy or sad, he may just repeat one

  of those answers and get it right just by accident.

1. In terms of how to measure development, it was good to do a pretest, and a post test. We showed the complete picture and asked how is the person feeling and got the participant's first response. Then run the app.
2. Then we may run the puzzle app while in the chair and teach the answer to the question how is the person feeling...repeating a few

times. Then do a post test, without the app and chair just show the complete picture and ask again how is this person feeling.

In Autism therapists use a teaching approach called ABA (Applied Behavior Analysis) and they teach by repetition and use rewards for the correct responses. At first therapist might give the full answer to the child and reward their response even if they are just copying the therapist. Then slowly the therapist will just give a clue, and reward the correct answer, but doesn't give them the chance to be wrong. If they are beginning to give the wrong answer the therapist quickly gives them the right answer instead. Slowly the therapist works her way up to getting the right answer without any help from the instructor. (This is just a very basic simplified description of some ABA strategies that are used in SAAAC.

Appendix B

Interviews

Questions to Therapist #1- Jennifer Cuellar – ABA Therapist at South Asian Autism Center (SAAAC), February 2016

Below conversation is recorded at the SAAAC with the therapist Jennifer Cuellar;

Q- What do you say about the sensory development?

A- A lot of the kids have behavior issues, not they are aggressive or anything, but they have repetitive behavior, they need stimulation or sensory input or they have too much sensory that they want to drawn out the world somehow, so because of this the chair might help a lot. Because of the tactile sensory issue having cushions or light being synched to iPad might help a lot.

Q- Do you think they can learn better with the help of the chair and the app in an environment like this, would it make any difference?

A-Once who have sensory issues would enjoy that as a reinforcement, or the calming effect on them that would help them learning face recognition and emotions.

Q- Can you say that the intervention which will be done with this chair and app is a type of directed play therapy, and what would be your contribution to perform the play therapy with children with ASD?

A- I do a lot of Natural Environment Teaching (NET) and Student Led Learning, which falls in play therapy interventions when it is suggested to be specifically focused on play therapy. As I said earlier in my sessions I try to pair fun activities with the target skills we are trying to teach. So when a learning activity can be embedded in a fun activity that is always a bonus and you can maximize your session time. Otherwise you are first doing the learning activity and following with the reward activity.

Therapist's Approach #2 - Dr. Jessica Franks – Child Psychologist at Hamilton Psychologist Services, November 2015

Q-What would you say it is the most important part of the therapy?

A-They are having problems with social skills. Most of the children cannot respond to their names, or cannot recognize facial expressions or emotions of others.

Q-What would you say about the face recognition development and sensory room setting being used together at the same time?

A-I think it is a great idea and there would be definitely benefits to use them together. Having a relaxed child in a sensory environment for sure would help to get them involved with a tool to learn from.

Q-What sensory tools are more beneficial to relaxation for ASD kids?

A-Every child is different. Some children enjoy furry textures while some cannot touch them. Mostly soft, coarse, shiny furry or squishy objects are preferable by most children.

Q-Do you use any technological tool or device during the play therapies?

A-We use IPads, children love to interact with them. Especially children who cannot communicate by talking response very well to electronic devices. They communicate through them or through the voices and pictures in them.

Q- Is there a technique you use to test their emotions, memory or learning? After each therapy or during therapies?

A-Showing them some pictures to observe their emotions is one way that we use.

Q-How do they play or what do they do for fun?

A-They mostly like technology. They interact with toys if therapist specifically interacts with them as a therapy tool.

Interview with parents

Q- How does the child communicate that he recognizes the face of others? How does the child communicate that he recognizes the emotions of others?

A-John can recognize easily close family members but the rest of people in his life. He can understand a happy person if happy or angry. Not necessarily sadness. He acts surprised by seeing new things like new toys.

Q-What are the sensory needs of your child with autistic spectrum disorder or which textures, sounds and objects that your child does not prefer to touch, hear or see?

A-John likes velvet texture. He has 3 blankets made out of same material, velvet. He likes also plush toys and soft furry textures. He does not like

Q-According to your own experience, what would make your child with ASD calm and relax most?

A-Computer games, basketball

Q-According to your own experience, what would you say if your child with ASD can recognize people and their facial emotions who are not in his/her daily routine easily?

A-No he can not

Q-Which types of games or play activities does the child enjoy the most?

A-Playing on iPad, going to school, watching movies on iPad, mostly Barney and Dora.

Q-What is the level of his engagement while playing? Can he memorize the action of the game for example fully or partially after playing?

A-John has a good engagement with games during and after. He memorizes games that he played before like car racing.

Q-Would you let your child to try a new game on iPad which aims to develop face recognition& emotions skills for children with ASD?

A-Yes

Q-Do you think people with ASD enjoy and/or relax in sensory rooms?

A-Yes

Q-Would you be interested in having a portable sensory environment in your home setting?

A-Yes

Q-Does your child seem to enjoy using technological devices? (Tablets, smartphones...) A-Yes very much

Q-If you knew there is a new tool for kids with ASD that combines music, sounds and sensory objects, would you be interested in trying it as a complementary part of the actual therapy? Please explain your answer.

A-Yes, and I want South Asian Autism Center to have this app and the chair for further interventions, also for my child to try periodically in his therapies.

Q-What type of physical position does your child play games on iPad? (Sitting, laying down, on a chair?)

A-He likes to sit and play.

Q-Which sensory tools can soothe your child's sensory disturbance if there is any?

A-Soft blankets, velvet. He likes Thomas blanket. He cannot touch unfinished wood surfaces. He does not like being hugged or squeezed. He also likes plush toys.

Q-Have you ever used any kind of assistive technology to recognize faces or emotions? Was it a game?

A-No

Q- In what environment is your child most relaxed? Can you please describe the child’s experience using the digital tool(s) in a relaxed environment if different than any other environment?

A-Living room, and he can play anywhere

Q-If you could design a tool for play specifically for your child, what would it be?

A-fast shooting games, running for a car game as he likes fast acting movements.