

TEXTURA:  
BEYOND CAREGIVING FOR ASD

by

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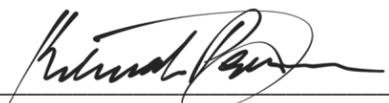
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# Abstract

Autistic children often struggle to convey their emotions to those around them, including their parents. Therapists and parents are thus bound by a common desire to offer autistic children a space to communicate their authentic selves, an effort stymied by both parental misreads and parent-therapist conversations that may talk past the child. This thesis investigates - through interviews with parents and therapists, and a survey of the literature - the possibility of strengthening these communications via Textura, a tactile+digital ecosystem. Textura communicates real-time emotional data to therapists and parents while simultaneously offering autistic adolescents an intuitively likable, tactile sensory experience. The tactile+digital ecosystem offers a new potential route forward for all stakeholders by allowing the child to emote, the parents to offer better and more fine-tuned emotional responses, and the therapists a novel source of information that could facilitate better therapeutic interventions.

Keywords: Autism, communication, tactile, emotions, therapy, sensory experience

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# Glossary

**ASD:** Autism spectrum disorder

**GSR:** or *Galvanic Skin Response*; a change in the electrical resistance of the skin caused by emotional stress, measurable with a sensitive galvanometer

**HR:** or *Heart Rate* the number of times the heart beats within a certain time period, usually a minute

**Meltdown:** an intense response to overwhelming circumstances—a complete loss of behavioral control

**Multi-User Design:** Designing for separate users within one ecosystem

**Neurotypical:** not displaying or characterized by autistic or other neurologically atypical patterns of thought or behavior

**Non-Verbal:** or *Non-Speaking Autism*; individuals with/without the ability to speak but/and lack the ability to use language in a meaningful way

**Sequential Research:** A research method that combines cross-sectional and longitudinal research by considering a number of different age groups and examining them at several points in time

**Tripartite:** shared by or involving three parties

# Introduction

Growing up in the compassionate household of a speech therapist and a special educator, I was introduced to children with Autism Spectrum Disorder (ASD) at an early age. Initially, I faced many difficulties in interacting with children with autism but seeing my parents decipher the wants of these children brought me to a place of understanding just by being present during those sessions. Furthermore, as professional therapists, my parents were able to understand the struggles of an autistic child within minutes of first meeting them, and to relay these struggles to the parents. Even as a child, I identified a gap in communication between the parent and an autistic child that was filled by guidance from therapists once a week. What was happening between the parents and the autistic child for the other six days? This observation has stayed with me till date, and formed the basis of research for this thesis.

Research<sup>1</sup> shows that a similar struggle can be found in parents with younger children, who have been recently diagnosed with ASD, while another study suggests<sup>2</sup> that when a previously verbal child suddenly stops communicating, parents are left in a tough spot. As humans, these parents depend on the known, i.e. verbal communication and *kinesics* (study of movements and gestures as a form of non-verbal communication) learnt as neurotypicals. However, being thrown into a situation where neither of these learned behaviors apply, parents are often distraught and overwhelmed. Seeing one's child screaming and not knowing why is a harrowing experience for any parent. But these difficulties represent only one side of the coin; Children with autism often *stim* (repetitive motions to help cope with emotions) and have visible ticks that could mean a plethora of things. To the untrained eye, these signs may all look the same.

Relying on years of experience and learning from trial and error, Autism Family on YouTube<sup>3</sup> breaks down a meltdown into six stages (*Fig B*) for other parents to learn from and understand.

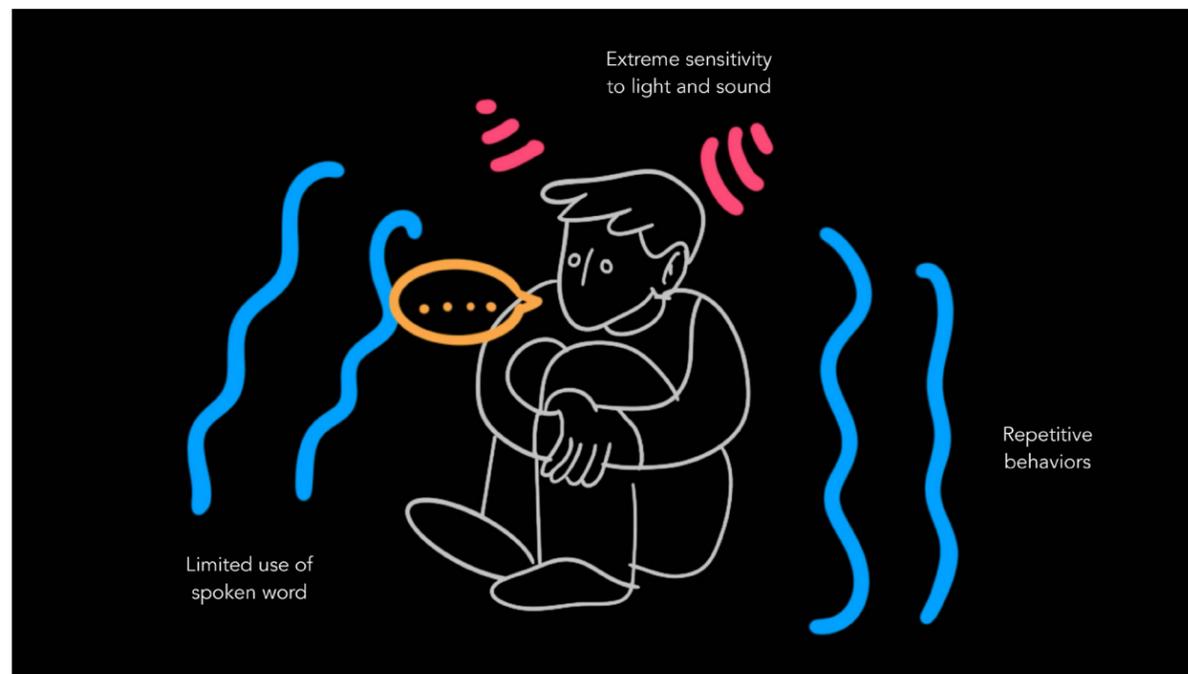


Fig A: Signs of autism

- 1 Midence, Kenny, and Meena O'neill. "The Experience of Parents in the Diagnosis of Autism: A Pilot Study." *Autism* 3, no. 3 (September 1999): 273–85. <https://doi.org/10.1177/1362361399003003005>.
- 2 Galpin J, Barratt P, Ashcroft E, Greathead S, Kenny L, Pellicano E. 'The dots just don't join up': Understanding the support needs of families of children on the autism spectrum. *Autism*. 2018;22(5):571-584. [doi:10.1177/1362361316687989](https://doi.org/10.1177/1362361316687989)
- 3 6 Stages of Autism Meltdowns, YouTube, 2018), <https://www.youtube.com/watch?v=kkZPbGXD66Y>.

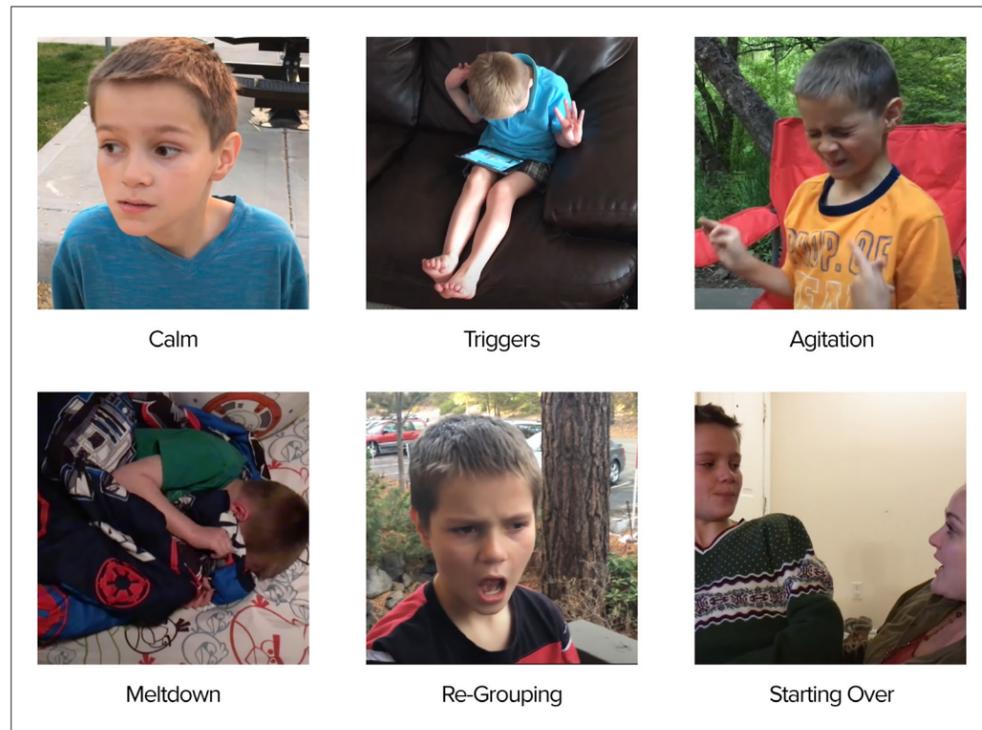


Fig B: Stages of a meltdown

**The stages of a meltdown for the specific child**

**Calm:** A state of normalcy

**Triggers:** Manifestation of small tics and coping mechanisms

**Agitation:** Increase in frequency and severity of tics and repetitive behaviors

**Meltdown:** Screaming and/or falling on hands

**Re-grouping:** An attempt to re-enter the family dynamic

**Starting-Over:** Having conversation about the meltdown with a parent

However these signals are true for their child and in the later half of the video they remind everyone watching that the uniqueness of each child can alter the way these stages manifest themselves. Tics and repetitive behaviors like hitting one’s face or making explosive hand gestures may be how one child copes, while another child may cope by covering themselves in a blanket or burying their head under a pillow. These non-verbal actions might also be non-existent, making dealing with this unknown

situation even more difficult.

Solutions and suggestions for various stages are given by the therapist from their experience with the specific child and previous children with ASD. These may range from checking for triggering sensations, to knowing when to approach the child, to methods of soothing. As young parents of children with ASD, decoding these levels and providing the apt response during a meltdown stage may prove to be overwhelming. In the case of non-verbal ASD, parents try their best to estimate feelings and emotional states, but may face difficulties as these methods of detection are arbitrary.

Therapists along with other non-familial caregivers who are also an integral cog of this system, provide solutions and develop strategies to best care for and aid in development of the child. They rely on their immense knowledge and experience to teach the child and assist the parent on how to navigate unknown situations. Therapists also reference their prior knowledge with other children to help them help another one.

The tripartite task of supporting a child with ASD can be visualized as three spheres working in sync to help the child succeed and grow the best they could (Fig C)

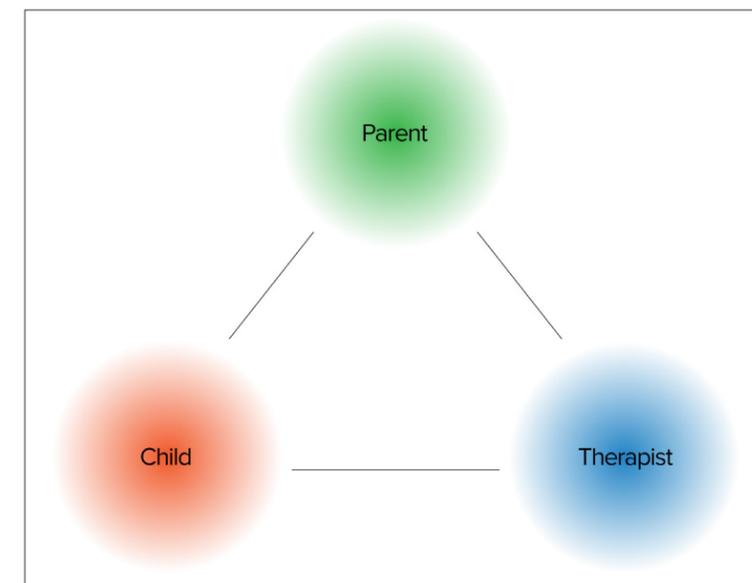


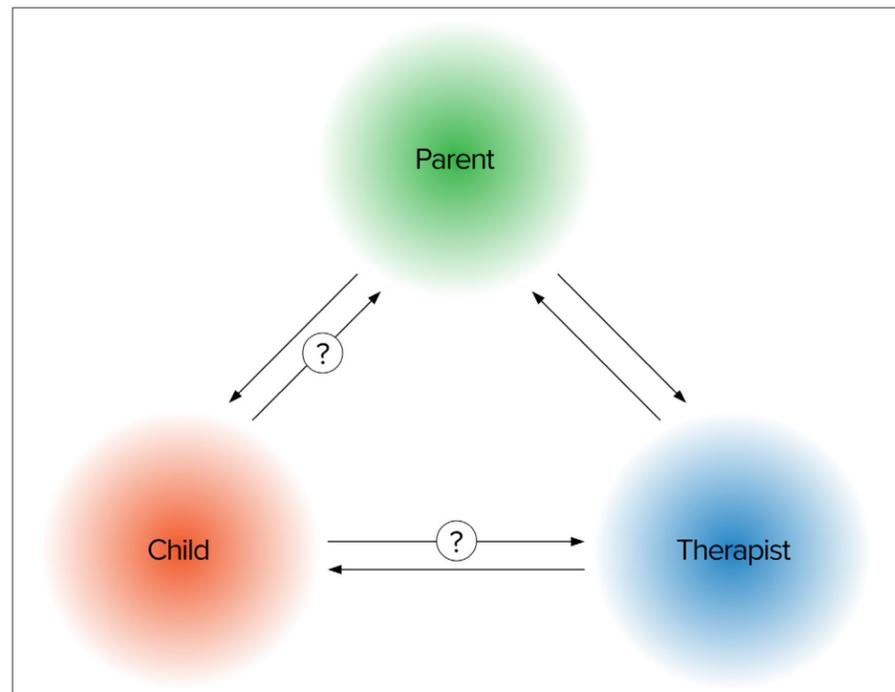
Fig C: The system of betterment

But unfortunately, current methods of communication are missing important connections on the emotional level. These connections are critical<sup>4</sup> for the overall growth of the child as they move into society and for the parent's own psychological well-being.

During stressful situations, parents do their best to comfort the child, utilize learnings from therapists, and eventually develop their own methodologies to deal with specific situations but may, at times, fall short on understanding the child's true needs.

The formative years of children with ASD are critical and this system requires all parties involved to work collaboratively. Currently, the parent and therapist have conversations and the therapist talks to the child, but there is a gap in communication between the child and parent and limits to what the child can tell the therapist, despite their years of experience (*Fig D*).

To solve for, and improve this gap in communication, this thesis proposes: Textura, a smart wearable that pairs with an app to help unravel non-verbal cues and effectively relay solutions for an autistic child's emotional changes to aid in communication. Maintaining engagement through textures and tactile experiences, the system alerts parents of emotional states of their child and future planning for therapists through direct data, thus bridging gaps in existing methods of communication.



*Fig D: The gaps in communication*

4 Erika Hernandez, Katie Carmichael, and Julie C. Dunsmore, "Toward Integrating Research on Parent–Child Emotion Talk and Linguistic Theory: A Spotlight on Parents' (in)Direct Communication," *Social Development* 30, no. 1 (2020): pp. 38-56, <https://doi.org/10.1111/sode.12472>.

# Chapter 1: Research

## 1.1 Autism : An Overview

The National Institute of Mental Health defines Autism or Autism spectrum disorder (ASD) as “A neurological and developmental disorder that affects how people interact with others, communicate, learn, and behave.”<sup>5</sup> A reliable diagnosis by an experienced professional can only be made by the age of two, yet a majority of individuals do not receive a full diagnosis until the age of nine<sup>6</sup>. As noted on the American Psychological Association’s website, “Autism spectrum disorder (ASD) refers to a neurodevelopmental disorder that is characterized by difficulties with social communication and social interaction and restricted and repetitive patterns in behaviors, interests, and activities.”<sup>7</sup>

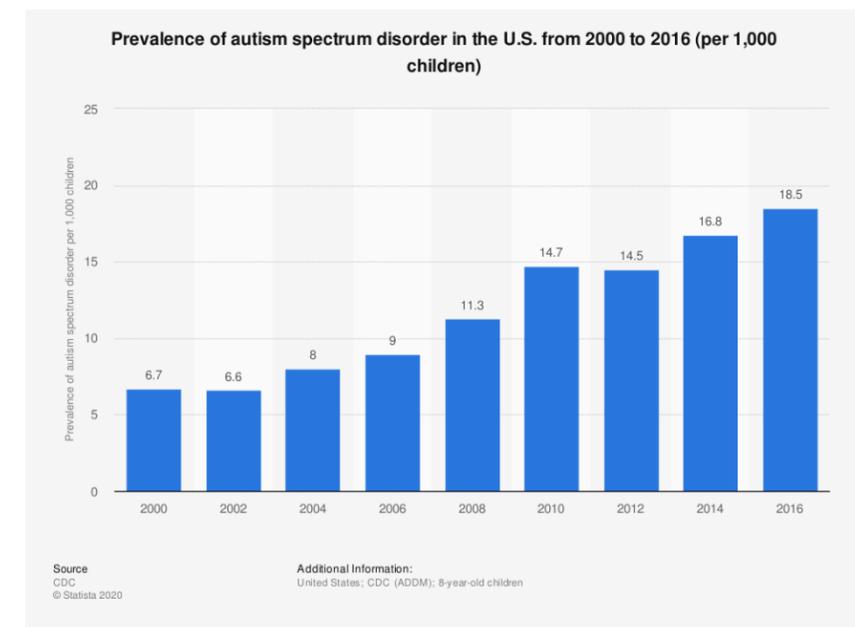


Figure 1.1: Prevalence of autism spectrum disorder in the U.S. from 2000 to 2016 (per 1,000 children)

- 5 “Autism Spectrum Disorder,” National Institute of Mental Health (U.S. Department of Health and Human Services), accessed March 27, 2022, <https://www.nimh.nih.gov/health/topics/autism-spectrum-disorders-asd>.
- 6 Catherine Lord et al., “Autism from 2 to 9 Years of Age,” *Archives of General Psychiatry* 63, no. 6 (January 2006): p. 694, <https://doi.org/10.1001/archpsyc.63.6.694>.
- 7 American Psychological Association “Autism and Autism Spectrum Disorders,”<sup>1</sup>

About 1 in 54 children have been identified with ASD according to estimates from CDC's Autism and Developmental Disabilities Monitoring (ADDM) Network.<sup>8</sup> The same survey shows a 176% increase in prevalence of autism spectrum disorder in the U.S. from 2000 to 2016 (*Figure 1.1*). With this rise in individuals with ASD, meaningful communication has become increasingly important.

Research suggests that the life of a person with ASD is often characterized by problems of understanding, including misunderstandings of linguistic context that helps one to interpret a verbal message.<sup>9</sup>

Therapists have the ability to deduce the emotional state and wants of a child with autism due to their years of study and experience.<sup>10</sup> Parents on the other hand, despite their countless hours with a child lack this professional training. This can lead to a disparity in parents being able to understand their child with autism at an early age due to a lack of initial experience and understanding of almost imperceivable differences in non-verbal communication. The problem does not lie with what the parent does or does not know, but with the fact that these behaviors in their child have to be learnt over time. One might expect these 'non-verbals' to communicate with us on our level, i.e. the verbal realm. As predominantly verbal communicators one might expect an individual with ASD to talk, reply or even hold a conversation with them, even when they are unable to do so, and when faced by someone who doesn't/ can not abide with 'what's normal', one might be lost. Through interviews<sup>11</sup>, it was found that this is prevalent in parents of children who are diagnosed with ASD, especially in the nascent stages of the child's development. Parents try their best to simplify sentences, break down words and a plethora of other

measures, but almost always fall short on understanding their dependent's needs during the early years.

The main reason for this gap lies with the fact that parents are trying to make the child understand them, and are seldom able to understand the child, especially in the state of a meltdown.

8 MJ Maenner and et al., "Prevalence of Autism Spectrum Disorder among Children Aged 8 Years"<sup>1</sup>

9 Loukusa et al., "Use of Context in Pragmatic Language Comprehension by Children with Asperger Syndrome or High-Functioning Autism," 1050

10 Wiklund, "Interactional Challenges in Conversations with Autistic Preadolescents," 77

11 Mishra, Dhruv. Your Experience with Autism. Personal, September 20, 2021.

## 1.2 The Human Body Speaks

Visualize yourself walking down a street, and a person walking past looks at you with their eyes widened. You would almost immediately think they were trying to tell you something. This gesture could be interpreted as a cry for help or as a show of surprise at seeing a familiar face. And, in those brief moments, two humans have communicated without saying a word.

Before one could externalize thoughts into the spoken word, humans were communicating with each other via physical gestures. This brought us to an understanding of when one was calling for our attention. Ingrained in our subconscious from time immemorial, we have employed non-verbal communication to ensure the survival of our species. And, even today, many lives depend on this form of communication such as children with ASD.

Before the advent of verbal communication, we were communicating with each other through hand gestures, our ancestors could tell when someone was calling for their attention. Ingrained and inherited in our subconscious from archaic times, we have employed non-verbal communication to the survival of humans as a species, to signal deadly plants or a predator's approach<sup>12</sup>. We use similar techniques in today's age<sup>13</sup> to inform our thoughts and decisions.<sup>14</sup>

Today when one speaks of communication, it's not just verbally, but also the language we speak physically. The way one dresses, the shifting of their eyes or

even the angle of one's foot, everything determines our intentions as humans. This understanding of semiotic language is known as kinesics and the Merriam-Webster dictionary<sup>15</sup> defines it as “*a systematic study of the relationship between nonlinguistic body motions (such as blushes, shrugs, or eye movement) and communication.*” Decades of research have gone into how altering one's body signals can lead to an increase in confidence and performance in social settings. One such paper from Harvard's Office of Scholarly Communication<sup>16</sup> shows a direct correlation between ‘power-posing’ and one's ability to seem more confident during an interview. Over the past century, humans have made various advancements in the field of kinesics, where humans have gone from understanding the importance of such non-verbal cues<sup>17</sup> to employing them when developing humanoid robots.<sup>18</sup>

However, our understanding of nonverbal communication is rooted in social and cultural contexts<sup>19</sup> and these understandings lead to our perception of what another person could be saying. As noted in *Humanity: An Introduction to Cultural Anthropology*<sup>20</sup> the grunting sound of ‘uh-uh’, has different connotations to it in different cultures. In Micronesian culture it means yes and it holds the exact opposite meaning to North American. The non-verbal cues one might learn in their early years, may not be

15 Merriam-Webster, s.v. “kinesics,” accessed October 5, 2021, <https://www.merriam-webster.com/dictionary/kinesics>

16 Amy J.C. Cuddy and et al, “The Benefit of Power Posing before a High-Stakes Social Evaluation,” accessed February 14, 2022, <https://dash.harvard.edu/bitstream/handle/1/9547823/13-027.pdf>.

17 Antje von Suchodoletz and Robert Hepach, “Cultural Values Shape the Expression of Self-Evaluative Social Emotions,” *Scientific Reports* 11, no. 1 (2021), <https://doi.org/10.1038/s41598-021-92652-8>.

18 Florian G. Kaiser, Karolin Glatte, and Mathis Lauckner, “How to Make Nonhumanoid Mobile Robots More Likable: Employing Kinesic Courtesy Cues to Promote Appreciation,” *Applied Ergonomics* 78 (2019): pp. 70-75, <https://doi.org/10.1016/j.apergo.2019.02.004>.

19 Lior Abramson et al., “Social Interaction Context Shapes Emotion Recognition through Body Language, Not Facial Expressions.,” *Emotion* 21, no. 3 (2021): pp. 557-568, <https://doi.org/10.1037/emo0000718>.

20 James G. Peoples and Garrick Alan Bailey, “2/Culture,” in *Humanity: An Introduction to Cultural Anthropology* (Boston: Cengage Learning, 2018).

12 Nicolas Fay et al., “Gesture Is the Primary Modality for Language Creation,” *Proceedings of the Royal Society B: Biological Sciences* 289, no. 1970 (September 2022), <https://doi.org/10.1098/rspb.2022.0066>.

13 Spencer D. Kelly et al., “Putting Language Back in the Body: Speech and Gesture on Three Time Frames,” *Developmental Neuropsychology* 22, no. 1 (2002): pp. 323-349, [https://doi.org/10.1207/s15326942dn2201\\_1](https://doi.org/10.1207/s15326942dn2201_1), 325.

14 Hui-Chieh Hsu, Geert Brône, and Kurt Feyaerts, “When Gesture ‘Takes over’: Speech-Embedded Nonverbal Depictions in Multimodal Interaction,” *Frontiers in Psychology* 11 (November 2021), <https://doi.org/10.3389/fpsyg.2020.552533>.

applicable in another setting. With our rich and diverse cultural history, it gets increasingly difficult to decipher such communication on a more personal level.

## 1.3 Communication with children

### 1.3.1. Parent-Child communication

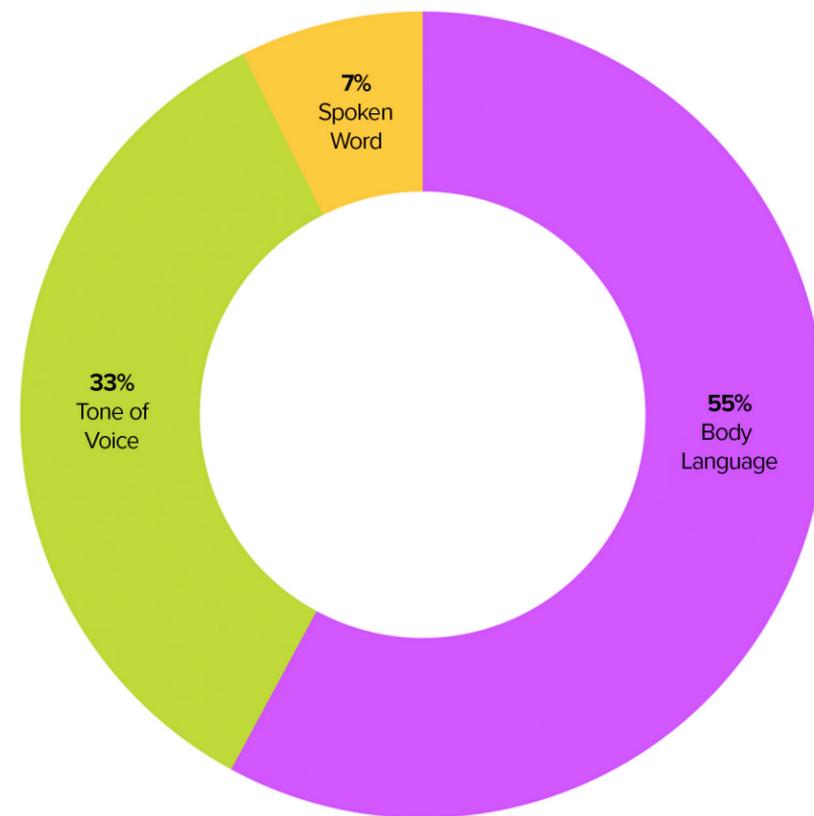


Fig 1.3.1.1: Diagram of Dr. Mehrabian's Model of Interpersonal Communication

Communication between a parent and their child is deeply personal and dynamic, guided (*unwittingly*) by verbal language and kinesics to such a high degree that the experienced adult can find out when their child is lying to them. This act of finding the truth when someone speaks otherwise, is driven by a rule of personal communication

hypothesized by Dr. Albert Mehrabian<sup>21</sup>. He formulated that words, tone of voice and body language account for 7%, 38% and 55% of communication on the personal level (*Fig.1.3.1.1*). Learned behaviors of non-verbal cues like leaning in or crossing arms during a conversation, is how one might make an inference of the intent of the other individual.

Keeping in mind that kinesics and the hypothesis by Mehrabian are most visible during personal communication, the importance of such interactions is paramount in parent-child communication.

### 1.3.2. Communication with ASDs

To bridge the gap in communication, it is crucial to identify emotional states of the child with autism and doing so is an elephantine task. Hence, the focus of this thesis will be to focus on fear and anger in the case of meltdowns. A meltdown is characterized by a sudden temporary loss of control over behavior, wherein the child can withdraw from the situation and refuse to interact at all.<sup>22</sup> This withdrawal and refusal to interact is often frustrating for parents and they may only worsen the situation by forcing the child to talk to them. It is natural for a parent to want to interact with their child in cases of distress, but knowing what exactly the problem is often impossible, especially in the case of autism. Knowing what caused a meltdown can be beneficial towards giving the correct response to the child.<sup>23</sup>

21 Albert Mehrabian and Susan R. Ferris, "Inference of Attitudes from Nonverbal Communication in Two Channels.," *Journal of Consulting Psychology* 31, no. 3 (1967): pp. 248-252, <https://doi.org/10.1037/h0024648>.

22 "Meltdowns - A Guide for All Audiences," National Autistic Society - Leading UK charity for Autistic people, accessed December 19, 2021, <https://www.autism.org.uk/advice-and-guidance/topics/behaviour/meltdowns/all-audiences>.

23 Hui-Chieh Hsu, Geert Brône, and Kurt Feyaerts, "When Gesture 'Takes over': Speech-Embedded Nonverbal Depictions in Multimodal Interaction," *Frontiers in Psychology* 11 (November 2021), <https://doi.org/10.3389/fpsyg.2020.552533>.

# Chapter 2: Approaching the Issue

## 2.1. Problem Definition

Autistic children operate at a tripartite communicative junction: this includes themselves, their parents, and their therapists. While each set of interactions generates its own peculiarities, autistic children - given their relative inability to emote in easily recognizable ways - require consistent and responsive attention from both parents and therapists. Autistic children communicate with their parents and their therapists, but the approach towards a solution is indirect: it is the parents and therapists who, despite centering the child, take decisions for them, communicating at the bipartite level. A *direct* knowledge of the child's emotional and cognitive states, however, is available *inconsistently* and in *different* ways to parents and therapists. Therapists diagnose autistic traits and their severity from a clinical standpoint, while parents leverage information from therapists and use their own situational awareness to understand the child's responses. Although both parties have the child's best interests at heart, it is ambitious to expect them to understand the child's specific responses in a concise, formalized format that offers accessible, real-time data. Textura helps eliminate this communication gap, offering parents and therapists a *simultaneous, standardized* picture of a child's emotional responses that facilitates better situational reading and more effective therapeutic strategising.

## 2.2. Methodology

In order to place and evaluate the needs of autistic children within the tripartite communication structure, it is critical to understand the range of responses parents employ to the challenges posed by emotionally inconsistent communication. For this reason, this thesis employs sequential research in the form of open-ended, semi-structured interviews with seven parents. This interview sample (*Fig 2.2.1*) consisted of seven interviewees: five mothers and two fathers. A semi-structured interview

protocol (attached in *Appendix I*) was used to elicit information on hypothetical and real-world responses to daily interaction scenarios involving their autistic children. Four respondents (*now referred to as- P1*) were parents to children aged 15 and above, while the remaining three (*now referred to as- P2*) (one man and two women) were parents of children within the target range (ages five to eight). This was supplemented by semi-structured interviews with seven child therapists: three child psychologists and four special educators. The broad focus of these interviews centered on parent-child communication structures and therapist feedback to parents.

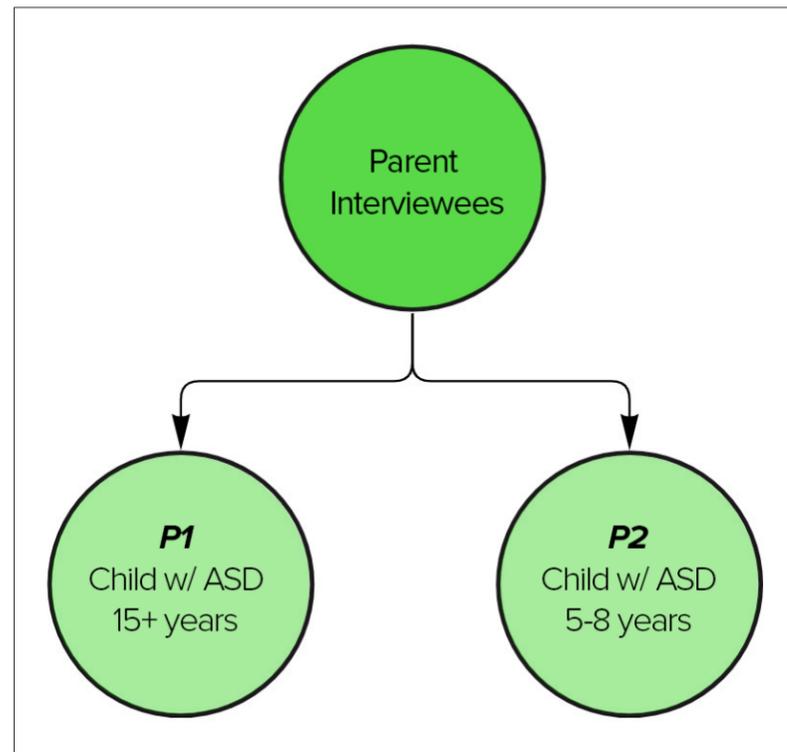


Fig 2.2.1: Parent group separation

The goal behind interviewing parents of children from different age groups was to better understand the variance in responses over time (sequentially). Parents who have raised autistic children for several years, despite an information gap, will have formed implicit and explicit strategies of engaging with difficult situations. Parents with younger

autistic children, on the other hand, are in the midst of a struggle to develop adequate care and response mechanisms. This likely prompts a different set of responses within stressful situations. The two interview groups were selected to offer supplementary knowledge that would better inform therapist interviews and product development. This thesis, therefore, aims to create an informational bridge between parents across generations and the therapists who work with them to help autistic children flourish.

Literature from the fields of autism and communication will be reviewed alongside schools of thought from behavioral psychology and physiognomy. The study of body language, specifically Oculistics and Kinesics will drive the project and the field of emotional prosody too will be looked into.

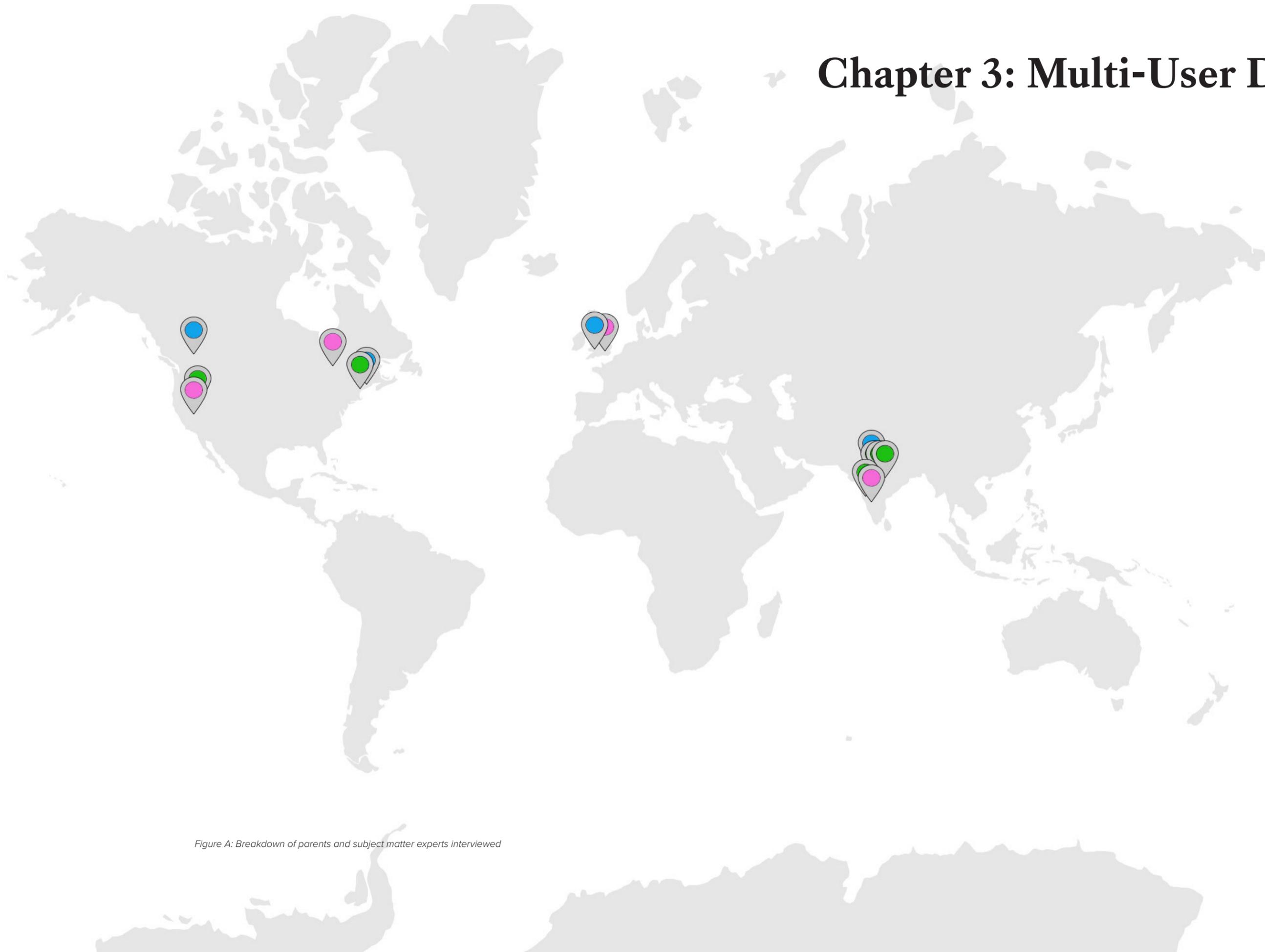
Institutional Review Board approval was sought and confirmed for all stages of this research.

## 2.3. Methods & Data Management

These interviews were conducted over a period of eight months between August 2021 and March 2022 through video conferencing. Interview recordings were saved on a hard disk and permanently deleted 3 months after completion of the MID Program (i.e., August 2022). Since the format of these open-ended ethnographic research interviews will be conversational and would loosely follow a pre-written script (*Appendix II*) in order to maintain a standard.

Another corroborating source of information for this study is the primary researcher's years of observation of children with ASD and their parents. These observations - a result of the PR's parents' careers as special educators - offer invaluable personal insights into the quotidian behaviors of the stakeholders within the tripartite communication framework.

# Chapter 3: Multi-User Design



-  Parents
-  Therapists
-  SME

Figure A: Breakdown of parents and subject matter experts interviewed

This thesis envisions a grounded tripartite approach that is beneficial to everyone involved: an intuitively accessible product for the child, accessible information for parents, and real-time strategising options for the therapist.

To design for children in the 5-8 year age group, the PR conducted landscape surveys of commonly used soft goods products. Parental feedback was used as the primary source of design and functionality innovation.. They were accordingly asked to recount their experiences from the early years and daily life, based on the age of the child. This was directed at identifying gaps in communication and emotive responses, and consequently streamlining design practices which could be used to overcome these gaps. The interviews with subject matter experts were used to discern potential loopholes and opportunities within current communication patterns and validate the design solutions based on their real-world experience.

### 3.1. Interviews with Parents

Following a pre-written script (*Appendix 2*), parents were asked questions about verbal communication and how they currently attempt to understand their child. These were supplemented by flexible prompts intended to further probe their responses. Interviews lasted approximately one hour each. Follow-up interviews were conducted within the same time range specified in the Methods section.

#### 3.1.1 Findings and Analysis

The interviews with parents from groups P1 and P2 were extremely informative and revealed several underlying factors were discovered over the course of eight months.

Parent A from P1 recollected, *“Initially, I didn’t know what was wrong”* when asked how they helped their autistic child when they were crying. When asked the same question, Parent B from P1 felt that they, *“Did the right thing”* during the stressful situation,

but *“...in retrospect, a few things may have been missed.”* Parents did not have a way of knowing if their solutions worked, or if they even were the correct ones. Parent C felt like they *“...were always on the back foot”* when it came to preventative care and things that they wouldn’t even notice like the whistling of a teapot or a night light might be a cause for meltdowns in their autistic child. When asked about how the therapist’s suggestions helped them, Parent D from P1 recollected, *“It was overwhelming at first but over the years I managed to make a mental cheat sheet for various situations.”*

Interviews with group P2 were focused on understanding and recollecting fresher experiences. Parent E from this group stated how they, *“...still do not know how he (referring to their autistic child) feels, because he doesn’t express himself.”* Parent F had similar feelings and said that, *“I don’t feel like I connect with him (referring to their autistic child) on the same level I can connect to his sister.”* They went on to add, *“This saddens me and I really don’t know what else I can do.”* Parent G felt, *“There is a deep connection between him (referring to their autistic child) and I but there is almost always room for improvement.”*

A common thread across all parent interviews is the use of a comfort object to soothe and help the children deal with a stressful situation. Some children even had this particular object with them at all times. It ranged from a soft toy to a blanket to the specific curves of one’s belt buckle. It is crucial to bear in mind that each of these ‘comfort objects’ had a sense of tactile materiality to them, be it the texture of a fabric or the smoothness of metal. Touch was the single defining comforter for children across ages.

It was found that the relatively inexperienced parents of younger children found it difficult to connect with them in their early adolescence - only with experience was a stronger bond formed. These parents would often misread the actions of their children, especially in the event of a breakdown - they attempted, instead, to diffuse the situation as quickly and effectively as possible. Parents tried methods (*Fig 3.1.1.2*) like giving the

child their favorite toy/ blanket or food, asking them questions to understand the reason, etc.

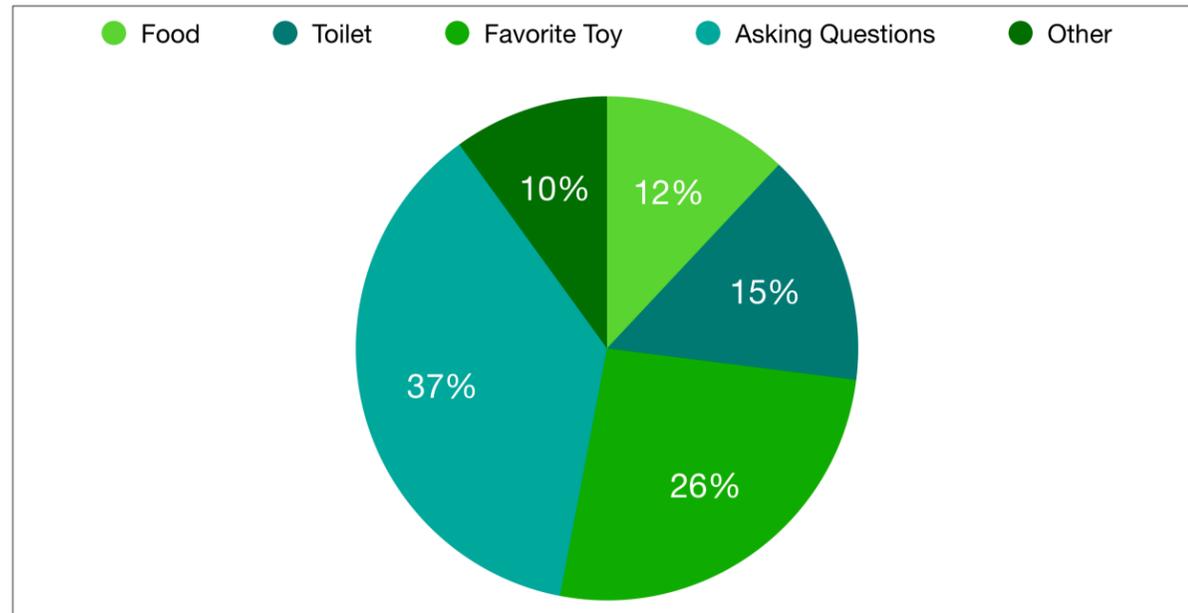


Figure 3.11.2: Methods employed by parents to deal with a stressful situation

By no means were responses completely unanimous. Parents did occasionally succeed at approximating their child’s emotional state and responding appropriately. Nonetheless, it was always past experiences which set the tone for subsequent ones. In only 30% of cases did parents believe that their responses were apt in relation to the situation, i.e., they felt they knew exactly what their child wanted (Fig 3.11.3). In around half the instances where the parent needed to interfere, they did not know whether their solution had worked or been appropriate.

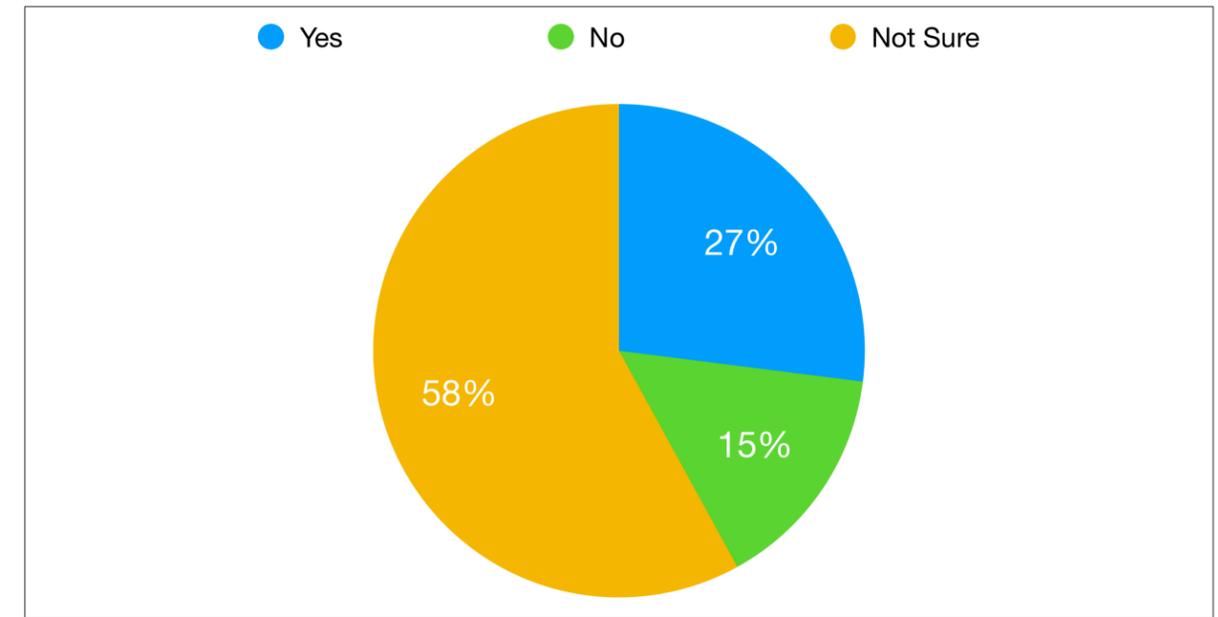


Figure 3.11.3: Was the response apt?

#### List of salient findings from first-hand experience of parents

- Connect on a deeper emotional level to the child
- The need to understand why the autistic child is acting a certain way
- How to better care for the child
- In a stressful situation- quick access to information given by a therapist
- A way to know if the solution worked

## 3.2. Interviews with Subject Matter Experts

The interviewed subject matter experts needed to be from diverse fields as the growth and development of a child with ASD lies in the hands of a large group of professionals, along with their parents. For this reason, child-psychologists, special educators, a lecturer of autism and a primary school teacher with years of prior experience were interviewed for the holistic improvement of this thesis.

In conversations with the **child-psychologist Upsanna Budhiraja** (Masters of Science in Human Development and Childhood Studies), she said that, “...oftentimes parents misread the signs and subsequently take an incorrect approach.” She also mentioned that children with ASD tend to stim (repetitive motions that one may use to help you cope with emotions<sup>24</sup>) and these actions are self-soothing and more often than not, they do not require the help of the parent. She added, “Like any other child, children with ASD can and do self-soothe and their lack of verbal communication should not be taken as a sign of incompetence.” Budhiraja also voiced that, “Ascertaining whether the presence of the parent in specific situations would be beneficial or detrimental to the child’s growth; the judgment lies in the hand of the parent.” In most cases, the presence of support is more than enough instead of what parents default to, i.e. over-parenting and trying to help their child as quickly as possible. Something that the parents fail to see, non-verbal cues these children could be sharing and it was reiterated that these cues only become apparent with years of experience. She also brought to attention that parents are given a plethora of solutions or fixes to issues, for example, to watch out for visual or auditory discrepancies in their child’s environment. It is the parent’s responsibility to make note of and remember these in times of distress.

24 WebMD Editorial Contributors, “What Is Stimming and What Does It Have to Do with Autism?,” WebMD (WebMD), accessed September 27, 2021, <https://www.webmd.com/brain/autism/what-you-need-to-know-about-stimming-and-autism>.

The special educator **Manisha Mishra** (HOD Special Education Dept. at Shiv Nadar School) mentioned that, “The development of weekly and monthly plans are an effective method to track and gauge the improvement of the child.” Here, the professional builds a plan and schedule which is improved with each visit. She said, “This is done solely between the parent and professional and I (the special educator) rely heavily on the input from the parent.” A question like “How does Child A usually feel after coming back from school?” , could help guide the educator formulate schedules and timings for remedial studies according to mood and energy patterns. The educator uses their experience to make the best plan possible from the information they get from the parent. It was also found that some parents do tend to leave out emotional data as it is often disregarded or taken as a mood swing. This lack of clarity can lead to slowing down the process of development plans and the more information the educator has, the better their planning would be. Mishra noted that, “Tactile sensory experiences can be extremely helpful in calming children with ASD” hence, the overarching presence of such an experience could prove beneficial in the development of this project.

The lecturer of autism, **Dr. Prithvi Perapa** (Doctorate in Philosophy, Autism and Cultural Perceptions, University of Birmingham) articulated the need for familiarization, i.e. the process of introducing a new element into the life of a child with autism. Due to the rigid pattern formations and desire to stick to routine, adding a foreign object can take time and in some cases fail. He also alluded to the concept of intersectionality of culture and autism and how different backgrounds could affect the outcomes of a design solution.

Primary school teachers also play a pivotal role in the progress of the child and in conversations with one such teacher, they stated, “I found it difficult to judge what a child with ASD might be feeling due to the lack of verbal communication. In the humdrum of the class the child is sometimes left out and in the case of a breakdown handling the child with ASD could prove troublesome with other children present, especially when

*the teacher does not know what the stressor is.*” Working in tandem with a special education teacher helped this primary school teacher employ better solutions during such encounters.

### 3.2.1 Findings

Through these interviews a few major points were brought to light and gaps in solutions became apparent. If one looks at the larger picture, it can be seen that the development of one child with ASD lies in the hands of a number of individuals. The parents, therapists and educators must work together as a unit to help the child with ASD reach their fullest potential. There must be a clear chain of communication between all the parties involved and working off each other’s smaller steps can help the child in the larger scheme of things.

What seems to be missing right now is early intervention methods for parents to better understand their child and understand their non-verbal language along with a way for parents to review and work towards improving their interventions. As the subject matter experts mentioned, parents have to go through a lot of information and methods before deciding upon the best possible one for their child, hence the simplification of this decision making would be ideal. Knowing when to act and what actions to take requires experience and time, something younger parents tend to lack.

#### Salient findings from therapists and other caregivers

- A medium to get data directly from the child
- A space where they can impart knowledge to parents in a more comprehensive way
- Use of tactile experiences to soothe and calm autistic children

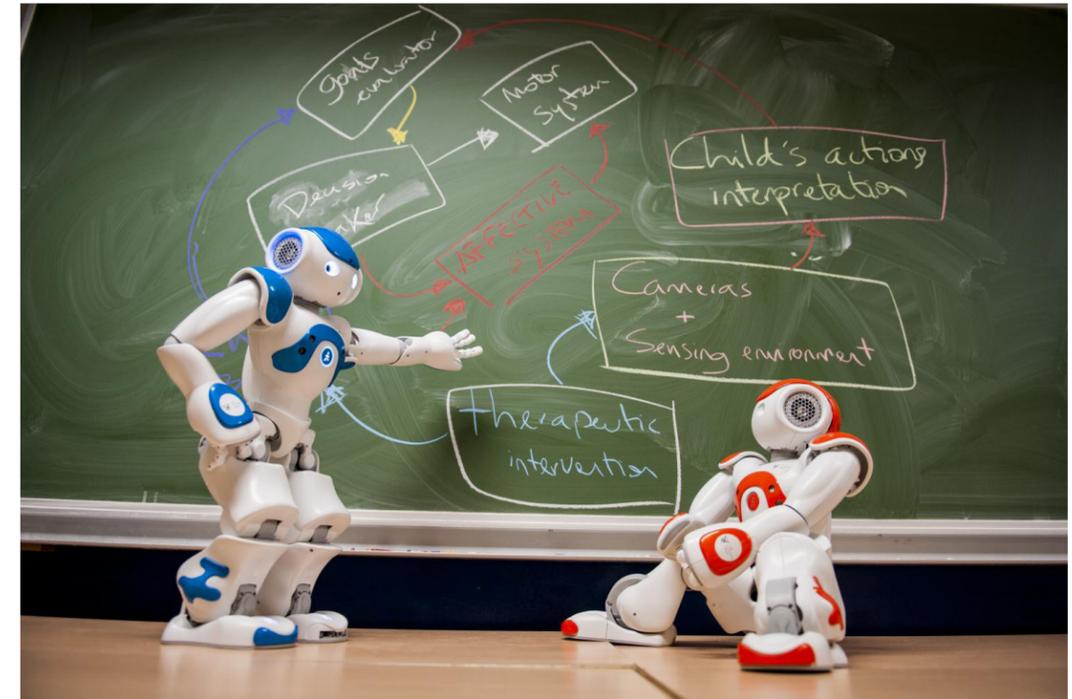
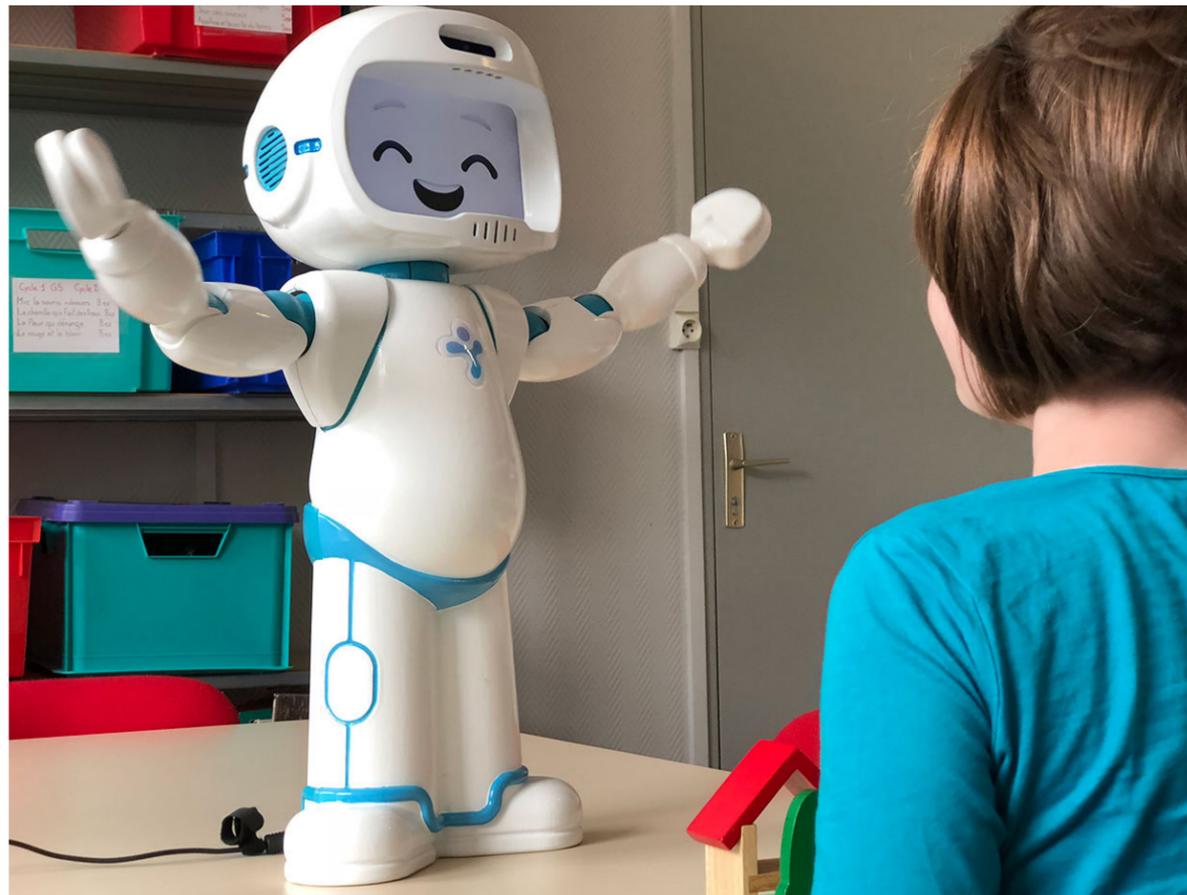


Figure 3.2.1.1: Majority of children with ASD have an affinity towards textures



Figure 3.2.1.2: Weekly plans and schedules with the therapist

# Chapter 4: Current Landscape



Various products/systems have been made with the intent of bridging this gap in communication between the parent and child. The parents of children with ASD can undergo training sessions<sup>25</sup>, which have proven extremely helpful but only in the cases in which parents have the time and patience to retain the information passed onto them. In today's fast paced world and with both parents working, these training sessions may often be overlooked. These sessions often include training in the use of picture cards and how to ask questions with direct 'yes/no' answers. While picture cards and monosyllabic answer questions are helpful, they remain as methods of trial and error. The parent has to ask the right questions and the child has to be in the mood to respond. Another issue arises in the form of associated learning disabilities that could come with autism. While these children may be gifted in some areas, others tend to lag behind when compared to the milestones of neurotypical children<sup>26</sup>. It is also important to note that current models of communication are initiated by the caregiver and there is a lack of non-verbal techniques that allow for the individual with ASD to influence the course of communication.

In the past five years, there have been various studies in the field of gauging facial and body movements to recognize intent. Milo<sup>27</sup> is a therapy robot that emulates basic human emotions to teach children with ASD how to improve their social and behavioral skills. The expectation from this product is to develop skills of the individual with ASD, which is an important life skill to have, and while this approach is widely accepted, the burden of communication still lies with the person with ASD.



Fig 4.1: Milo interaction with autistic children

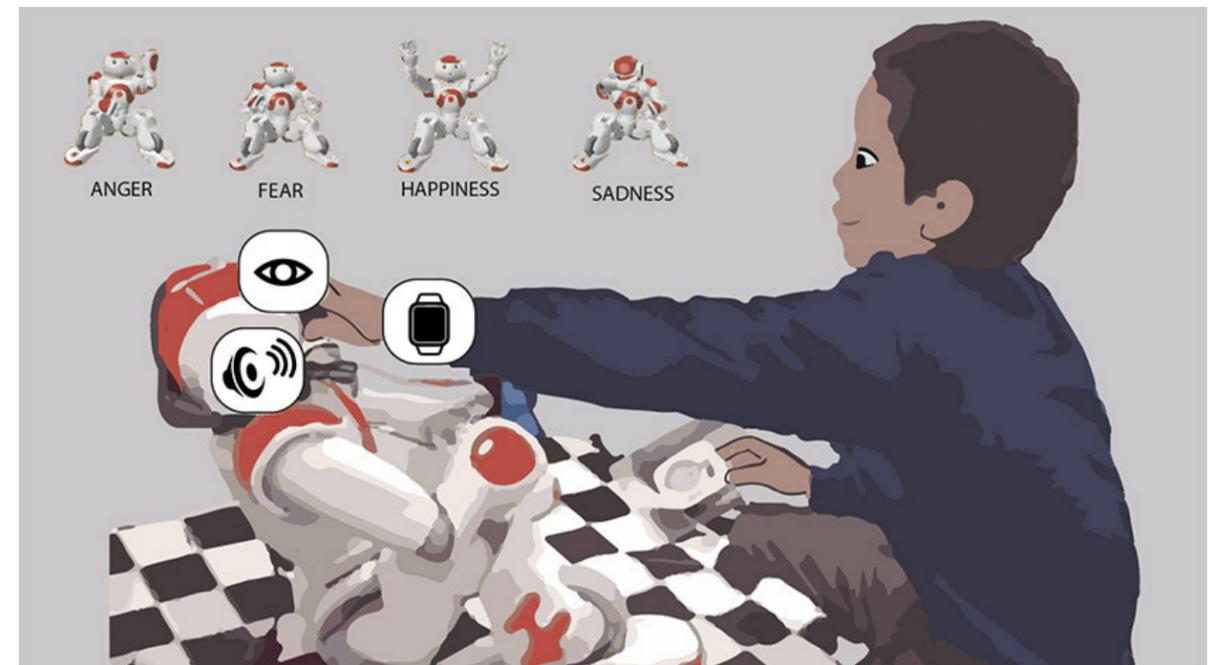


Fig 4.2: Emotion depiction through the EngageMe robot

25 "Autism Caregiver Training: Helping Families," Autism Speaks, accessed May 3, 2021, <https://www.autismspeaks.org/science-news/autism-caregiver-skills-training-helping-families-home-and-abroad>.

26 Rebecca J. Landa et al., "Developmental Trajectories in Children with and without Autism Spectrum Disorders: The First 3 Years," *Child Development* 84, no. 2 (2012): pp. 429-442, <https://doi.org/10.1111/j.1467-8624.2012.01870.x>.

27 LLC RoboKind, "Meet Milo!," Robots4Autism, accessed October 17, 2021, <https://www.robokind.com/robots4autism/meet-milo>.

EngageMe<sup>28</sup>, a personalized machine learning robot, was developed by researchers at the MIT Media Lab. This project aims to build a new technology to enable automatic monitoring of affect and engagement of children with ASC (*Autism Spectrum Conditions*) in communication-centered activities by evaluating affective states. EngageMe uses bio-data from a wearable and correlates that data with eye tracking cameras to detect level of alertness in the child. This project works towards understanding the person with ASD's emotional state and making the experience of interacting with a robot more natural for the individuals with ASD, but falls short of delivering that data to the caregiver. Without an actionable output, this device serves the purpose of an information gathering device geared towards improving existing therapy. The bridge between parent and child is left incomplete. Furthermore, all solutions are tailored to help only the parent-child unit. The therapist may often be left out of the conversation and they end up relying on the parent's interpretation of events.

Recognizing this incomplete bridge and understanding that non-verbal communication takes time and experience to utilize to its best, a possible solution lies with technology, specifically emotion sensing systems. There has been research<sup>29</sup> into various types of methods and sensors by which the instantaneous emotional state of an individual can be estimated within reasonable bounds. Such technologies include but are not limited to Galvanic Skin Response sensors<sup>30</sup> and TrueDepth cameras<sup>31</sup> which can

take into account a person's biometric and facial data respectively. Artificial intelligence is also important for this project as it can harness quantitative data, which is imperceivable to humans, to make reasonable assumptions for what it is measuring<sup>32</sup>. An AI analysis of such data can reap long term benefits and as the model learns over time. Paired with a Generative Adversarial Network (GAN)<sup>33</sup> an ever-learning AI could evolve and predict emotional states for other children with autism as well.

28 Rosalind W. Picard, "Engageme Chosen as an EU Research Success Story," MIT Media Lab, accessed July 23, 2021, <https://www.media.mit.edu/posts/engageme-horizon/>.

29 Tapotosh Ghosh et al., "Artificial Intelligence and Internet of Things in Screening and Management of Autism Spectrum Disorder," *Sustainable Cities and Society* 74 (2021): p. 103189, <https://doi.org/10.1016/j.scs.2021.103189>.

30 Dindar S. Bari et al., "The Correlations among the Skin Conductance Features Responding to Physiological Stress Stimuli," *Skin Research and Technology* 27, no. 4 (2020): pp. 582-588, <https://doi.org/10.1111/srt.12989>.

31 Simon Andre Scherr, Christian Kammler, and Frank Elberzhager, "Detecting User Emotions with the True-Depth Camera to Support Mobile App Quality," 2019 45th Euromicro Conference on Software Engineering and Advanced Applications (SEAA), 2019, <https://doi.org/10.1109/seaa.2019.00034>.

32 Tapotosh Ghosh et al., "Artificial Intelligence and Internet of Things in Screening and Management of Autism Spectrum Disorder," *Sustainable Cities and Society* 74 (2021): p. 103189, <https://doi.org/10.1016/j.scs.2021.103189>.

33 Jun Deng et al., "Speech-Based Diagnosis of Autism Spectrum Condition by Generative Adversarial Network Representations," *Proceedings of the 2017 International Conference on Digital Health*, February 2017, <https://doi.org/10.1145/3079452.3079492>.

# Chapter 5: Minimum Viable Product

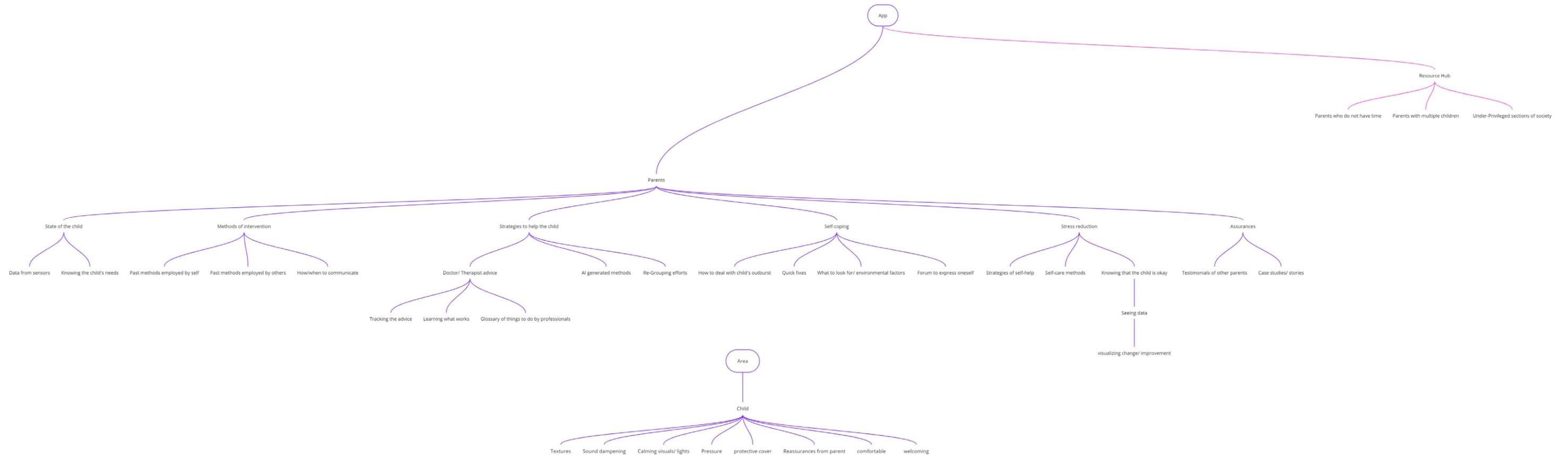


Figure 5.1: MVP for design considerations

Extrapolating from the interviews conducted with parents and subject matter experts, there lies a gap where design could prove beneficial in terms of creating a better experience by strengthening emotional bonds between parents and children with ASD. There is a latent desire for younger parents towards knowledge they lack and solutions for their children, especially in situations of distress. Along with that, parents would need information at their fingertips and quantifiable measures for the same.

Taking into account the knowledge from research and interviews and the fact that tracking the heart rate and skin conductance can lead to estimating<sup>34</sup> the emotional state of a child with autism, the aim of this project is to gauge emotional states of children with ASD, unravel non-verbal cues and effectively relay solutions to their parents.

Armed with the knowledge of what the body is saying and the child can not, the parent can focus on dealing with the situation rather than identifying emotional states, especially in a stressful situation. Removal of the identification step can ease the process of situation resolution for the parent, leading to lesser stress levels<sup>35</sup>. The thought that the parent may feel incompetent arises, but the inability to correctly detect the situations currently is a similar conundrum. The project focuses on parents whose children have been recently diagnosed with ASD, the ones who do not have the technical know-how of these subtle non-verbal cues. Additionally, the system also should also serve a hub of intelligence for parents to draw from and act upon.

To sum it up, the minimum viable product for this research topic (*Fig 5.2*) would be to detect, gauge and relay emotional signals of children with ASD, derived from biofeedback to their parents in order to provide better care and build a stronger emotional bond between them. Additionally, tightly coupling the interaction and transfer

34 Chin-An Wang et al., "Arousal Effects on Pupil Size, Heart Rate, and Skin Conductance in an Emotional Face Task," *Frontiers in Neurology* 9 (March 2018), <https://doi.org/10.3389/fneur.2018.01029>

35 Susan Bonis, "Stress and Parents of Children with Autism: A Review of Literature," *Issues in Mental Health Nursing* 37, no. 3 (March 2016): pp. 153-163, <https://doi.org/10.3109/01612840.2015.1116030>.

of knowledge between the stakeholders is another important aspect of this system.

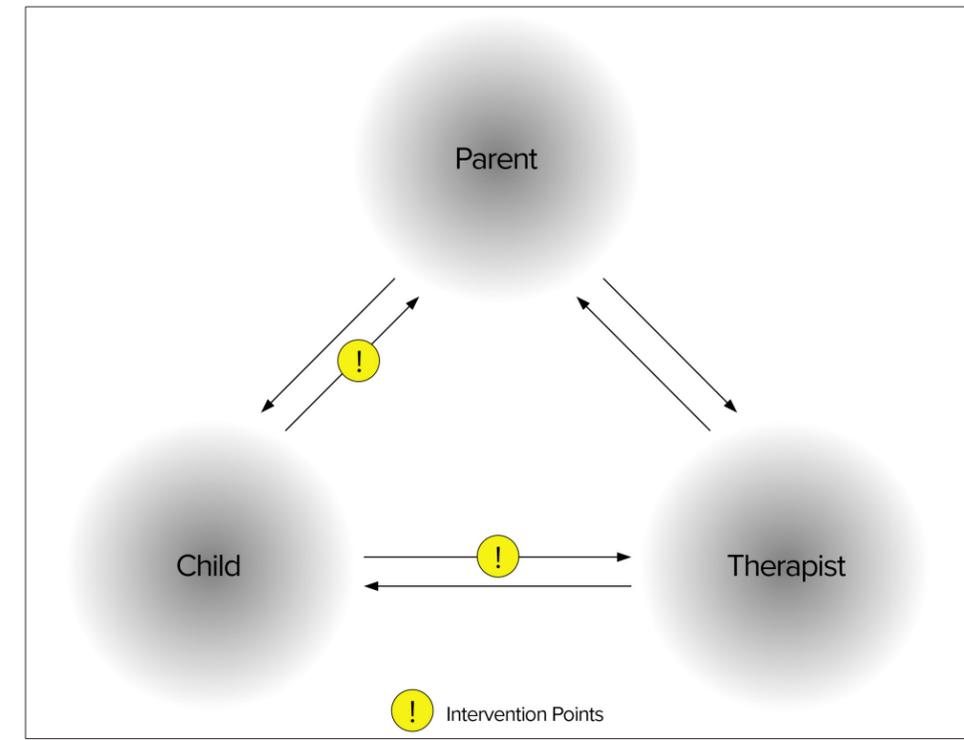


Figure 5.2: Possible intervention points

Keeping in mind that possible solutions would be most effective in the early years of development, the target age group for this thesis would be parents of children with ASD in the age group of 5-12 years. This decision was made as this is when it was found that parents found the most difficulty in understanding their child and the children are most open to new experiences.<sup>36</sup> This age group also allows for further exploration into artificial intelligence and pattern formation that would be beneficial to therapists in furthering and collating knowledge on ASD.

The emotional impact and affordances of such a product would be questioned, and an attempt to mitigate these would be later in the thesis.

36 "Stages of Growth Child Development - Early Childhood (Birth to Eight Years), Middle Childhood (Eight to Twelve Years)," *StateUniversity.com*, accessed January 8, 2022, <https://education.stateuniversity.com/pages/1826/Child-Development-Stages-Growth.html>.

# Chapter 6: Design and Development



## 6.1. Design Solutions Physical

The first round of ideation started with keeping available technology at the forefront and building a system of products for the child and the parent. This process started off by taking into account the various interviews and findings and mapping out situations in which a child might need the parent to understand them. Being mindful that this research deals with non-verbal children, concepts were developed in which verbal contact was out of the question.

To better understand the intricacies and user flow, user scenarios were made with information from parents, therapists and other caregivers.

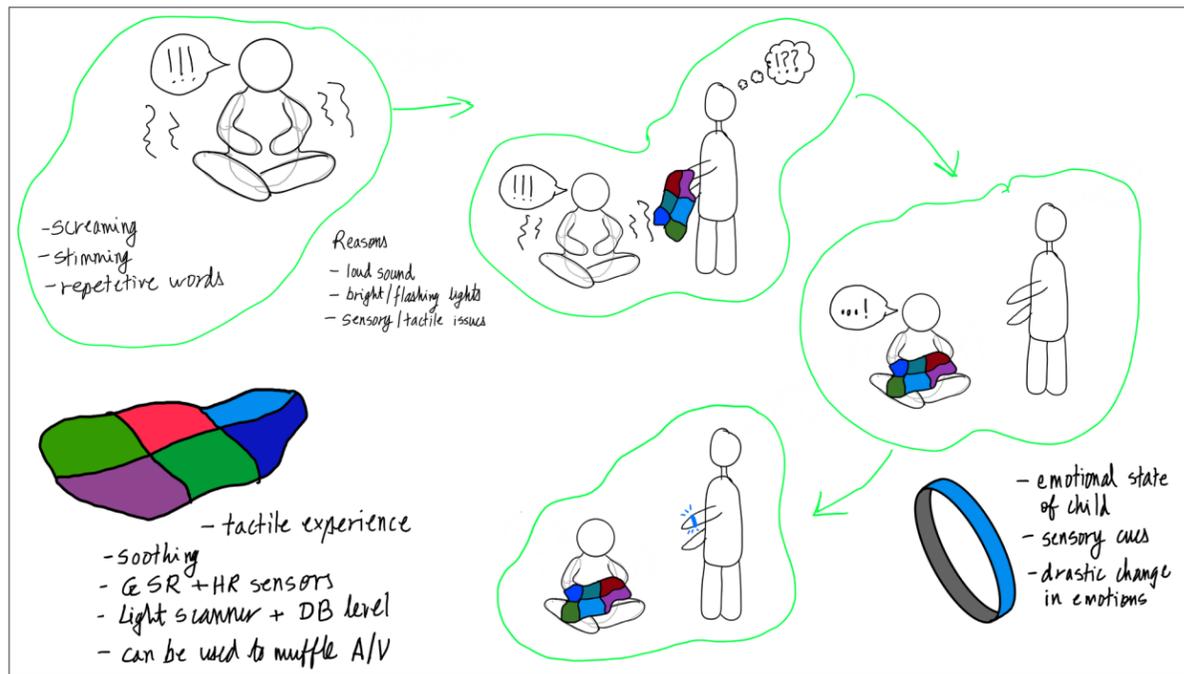


Figure 6.1: User Scenarios for Child and Parent

### 6.1.1. The Child's End

While designed for a child with ASD a springboard for design inspiration came from employing and improving existing products as they would be most accustomed to them. Hence, the ideation started off with adding cameras and sensors to daily objects (Fig 6.1.1) like blankets, speech therapy mirrors and cushions, which are used for comfort, remediation and specific area seating respectively.

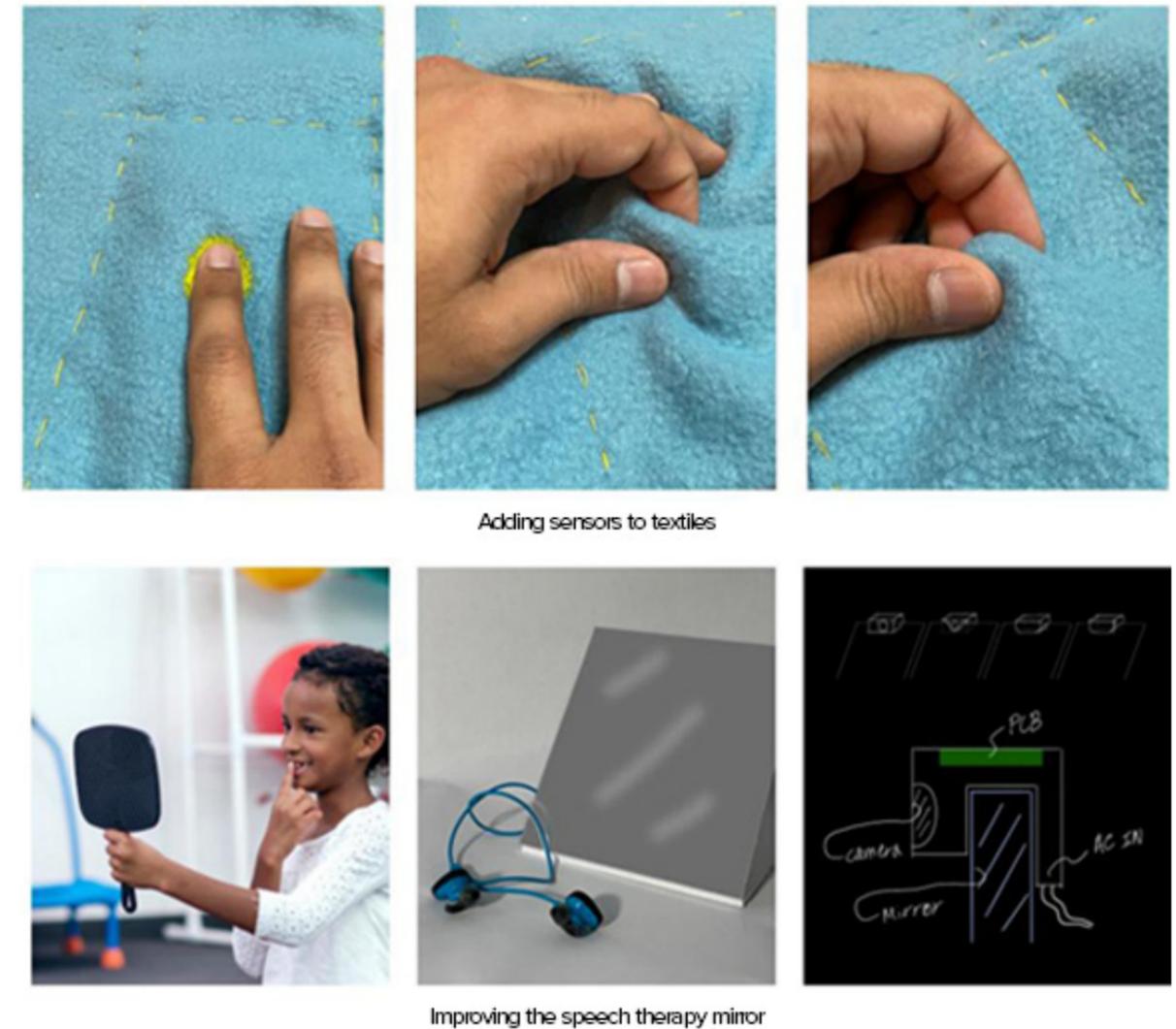


Figure 6.1.1: Enhancing existing products



Figure 6.1.2: Placement of product

Another design concept was to introduce objects with least distraction into the home environment, for which the ideation of cameras came into being. Influenced by the care a parent provides a child (Fig 6.1.3), these cameras would track micro-movements and analyze body language to help the parent provide the best care to their child.

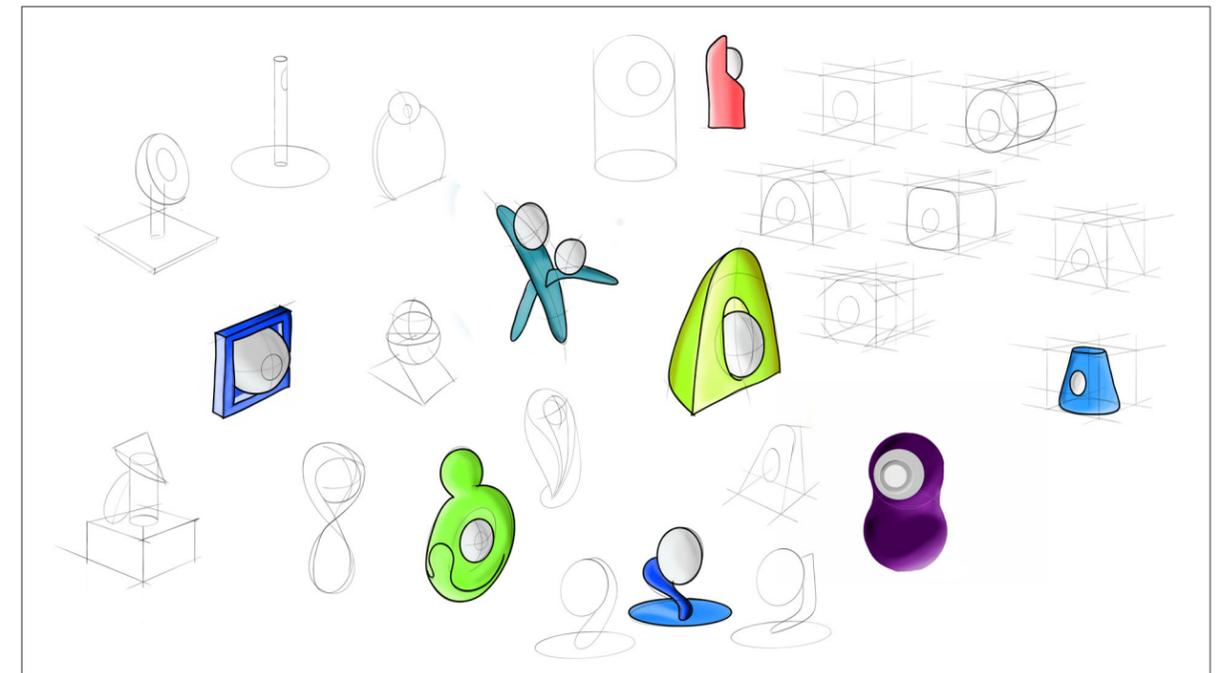


Figure 6.1.3: Vision systems taking inspiration from care

On further analysis and consultation from the advisors and SMEs these ideas needed to be further developed as they were targeting specific areas and an integrative product was missing. The mirror and cushion would only be used under specific conditions and the potential algorithm would face issues in creating a seamless system. The camera, on the other hand, was not the most popular choice of the parent stakeholders playing into the general fear of monitoring and privacy issues.

Another initial idea was of tactile pebble pairs (Fig 6.1.3) for the parent and child, wherein an organic and ergonomic handheld form would be used to capture and relay emotional data. The child's end would house the GSR and HR sensors, and the parent's end would have visual and haptic feedback to relay the emotions of their child.

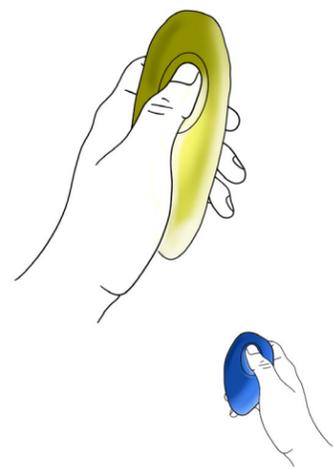


Figure 6.1.3: Pebble Pairs

The issue arose of losing a small device like this and co-designing with the therapist gave insight on how this may not be easy to find in the case of a meltdown. In a follow-up interview with the lecturer, it was mentioned that this device would take some getting used to for the child and successfully predicting the correct use of it may prove to be troublesome.

In order to combat these issues, an iteration of the blanket was focused upon wherein the existing comfort fabric could be embedded with technology (Fig 6.1.4) in order to gather and gauge emotional data.

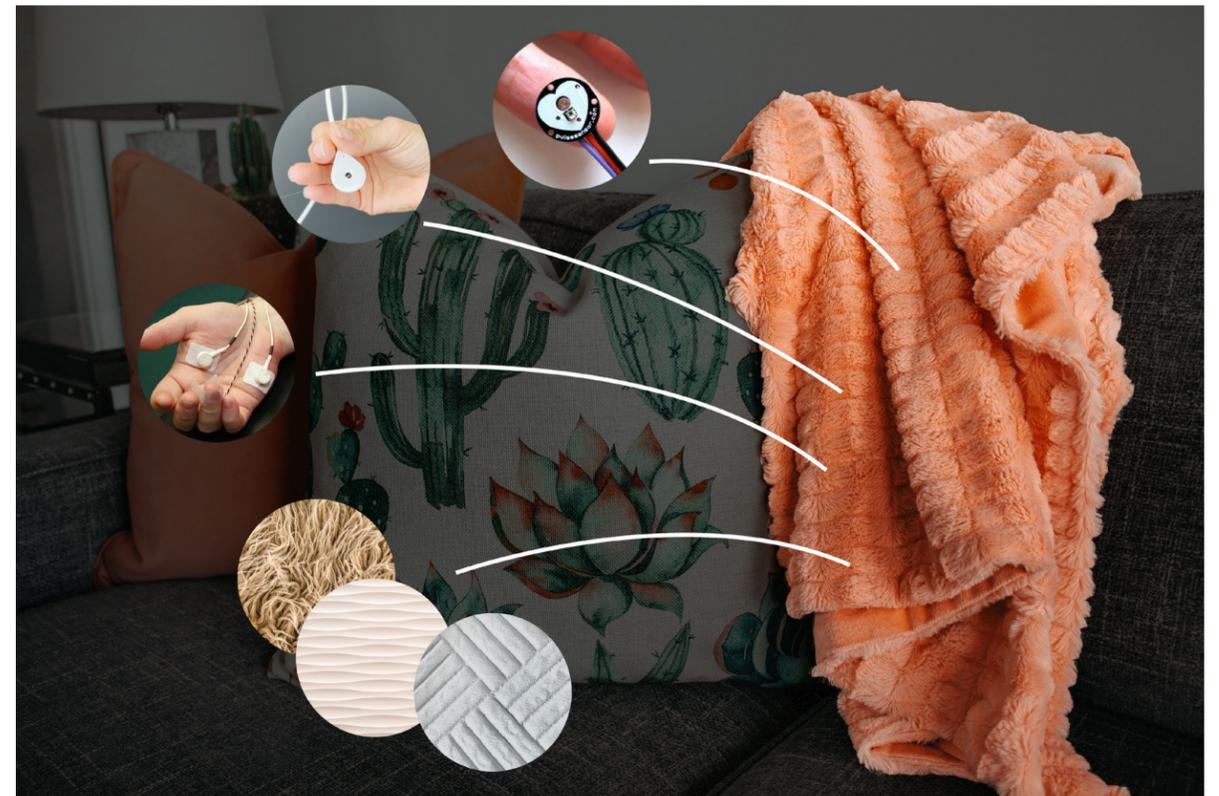


Figure 6.1.4: Tactile Blankets

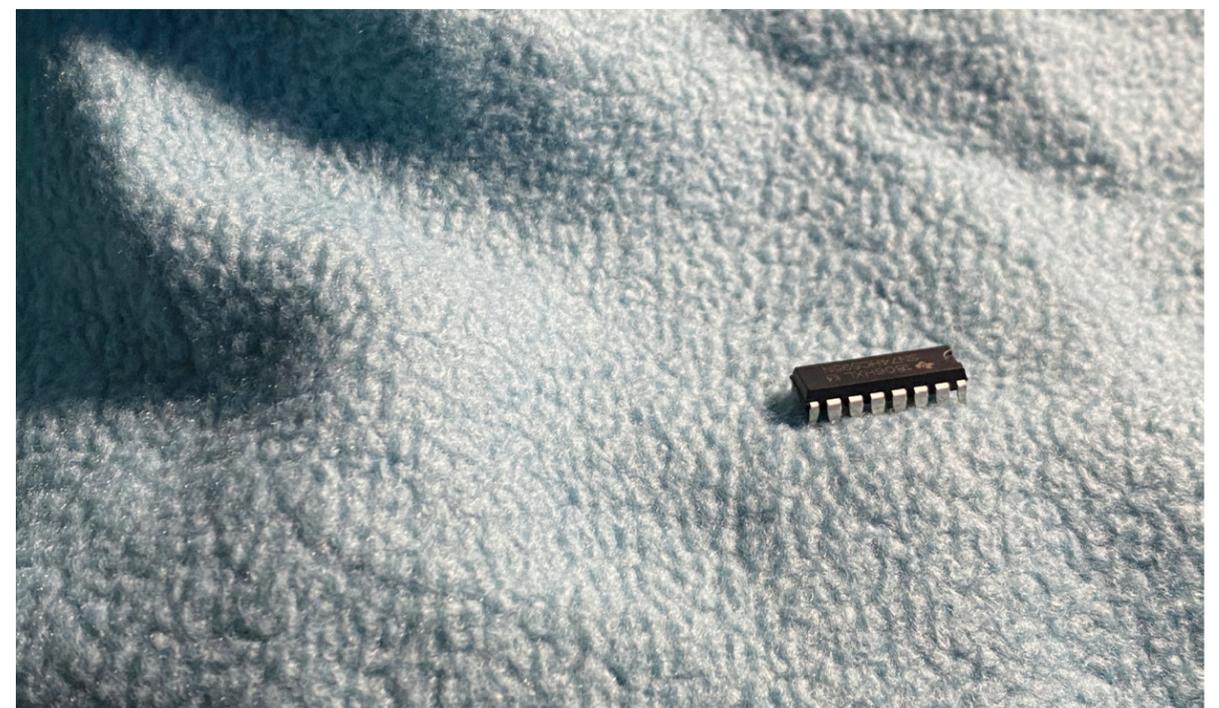


Figure 6.1.5: Embedding technology into an existing 'comfort' blanket

This concept would prove to be logistically unfeasible as adding these technologies would require outside external aid and furthermore might alter the appearance of the fabric, to which these children are attached.

Following the iterative process and feedback from the various stakeholders, another concept proposed was of a tent (Fig 6.1.6) where the child could play and use as a safe space. This would act as a buffer zone where the child could be free to express their emotions and using sensors this information could be relayed to the parent.

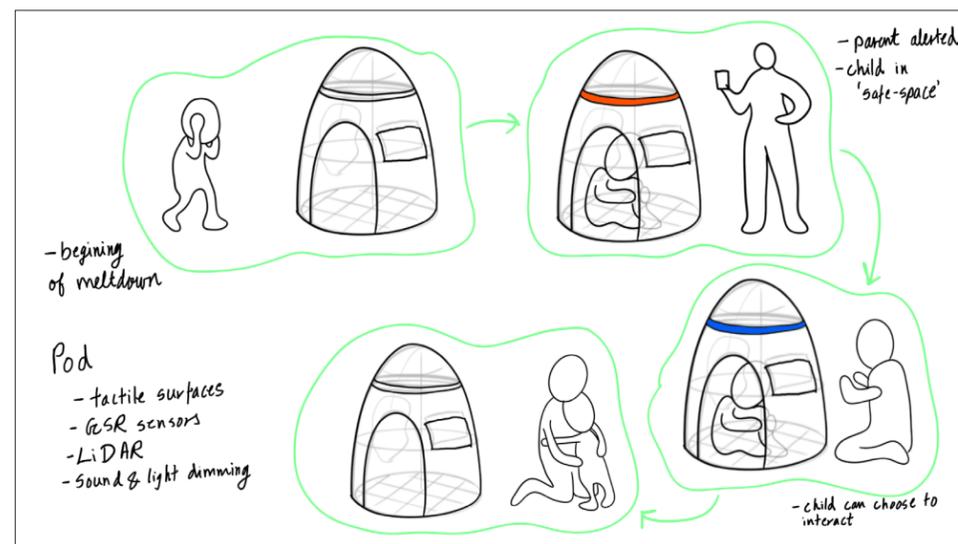


Figure 6.1.6: Emotion Sensing Tent



Figure 6.1.7: Wall mounted textures with smart glove



Figure 6.1.8: Jacket with pockets which have embedded sensors

In the same vein of comfort and embracing the idea of a hug the concept of a jacket (Fig 6.1.8) was proposed. This would house the sensors necessary to track and analyze emotions in the hand region. The same could be achieved with a wall mounted fixture paired with a glove. Alongside that, another concept of a wearable pouch was proposed (Fig 6.1.9).

The concept of the pouch was taken forward as it served as companion for the child whilst maintaining a small size which could be carried on their person without too much of a hassle. The initial round of prototypes (Fig 6.1.10) were made to assess the size, scale and possibilities for pouches for children in general.

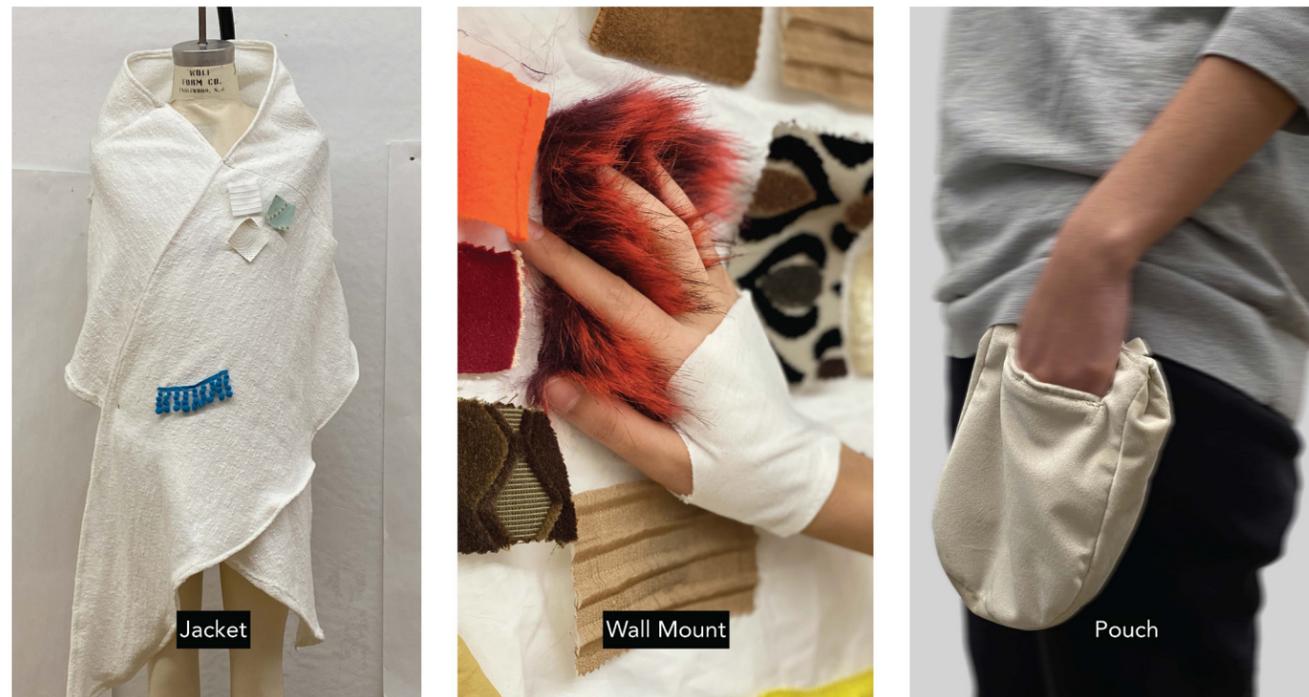


Figure 6.1.9: Jacket vs Wall Mount vs Pouch



Fig: 6.1.6: The first prototypes of the pouch

## 6.1.2. The Parent's End

Tackling the issue of information transfer, it was imperative to design an experience for the parent to receive and understand the data. Additionally, this product must provide solutions to parents on how to act and best aid their child.

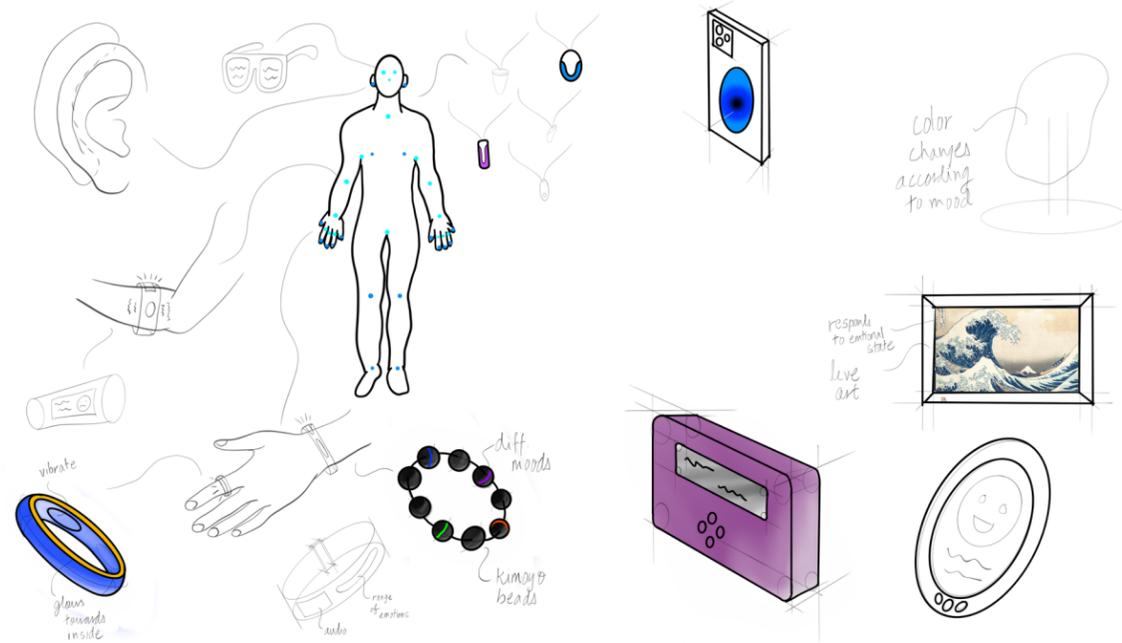


Figure 6.2.1: Data Representation

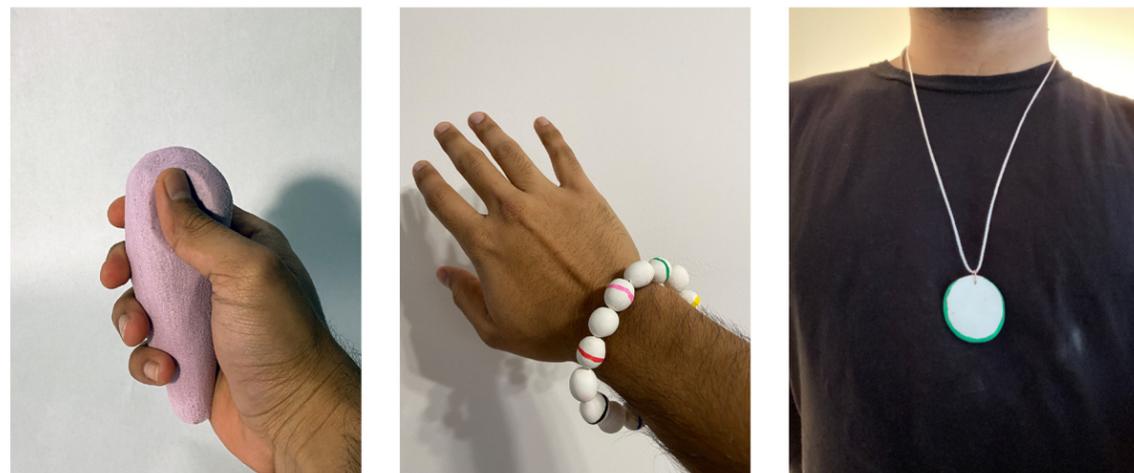


Figure 6.2.1: On/Near Body solutions

The initial ideation was focused around physical wearables (Fig 6.2.2), with the pebble pair (*parent side*) to act like a beacon and give feedback through visual and haptic means. The necklace was a wearable version of the pebble pair, making the form more discreet. The tech-laden kimono beads would serve a similar purpose on the wrist or around the neck, with each bead being used to deliver specific signals.

On conferring with parents and other stakeholders, it was suggested that learning the responses would prove to be a larger learning curve for some parents. Also deciphering the visuals and vibrations might prove to be more stressful when their child is in duress. Hence in order to simplify the process the concept of an app was proposed. Also as fore-casted in WGSN's 2022 Future Consumer report<sup>37</sup>, the year "2020 has been heralded as the dawn of a connected decade" with 2022 being the year wherein humankind solidifies the connection between technology and self.



Figure 6.2.2: Collection of data into a mobile device

Since the product would be using a form of artificial intelligence, having a central

37 Andrea Bell, "Executive Summary Future Consumer 2022 - WGSN," WGSN, accessed March 31, 2022, [https://www.wgsn.com/assets/marketing/WGSN\\_Future\\_Consumer\\_2022\\_Executive\\_Summary.pdf](https://www.wgsn.com/assets/marketing/WGSN_Future_Consumer_2022_Executive_Summary.pdf).

hub to process and visual data would be beneficial. The app serves as a hub of information collection, disbursement and cataloging, in order to give the more effortless and swift feedback to the parent.

## 6.2. Design Solutions Digital

The design of the app started from understanding what each stakeholder from the unit would require. The parent would like to know their **child's emotional status** and how to act in certain situations. The therapist would like to **check on the child's progress** in order to best customize the weekly/ monthly plan and goals accordingly. This system should be straightforward and have quick to understand graphics. Especially in cases of a breakdown, where the parent can not focus on multiple things at once, the app should serve as a facilitator rather than an impediment to the process.

To start the process, the interactions and steps were broken down into a flowchart, leading to the creation of a breakdown (Fig 6.2.1)

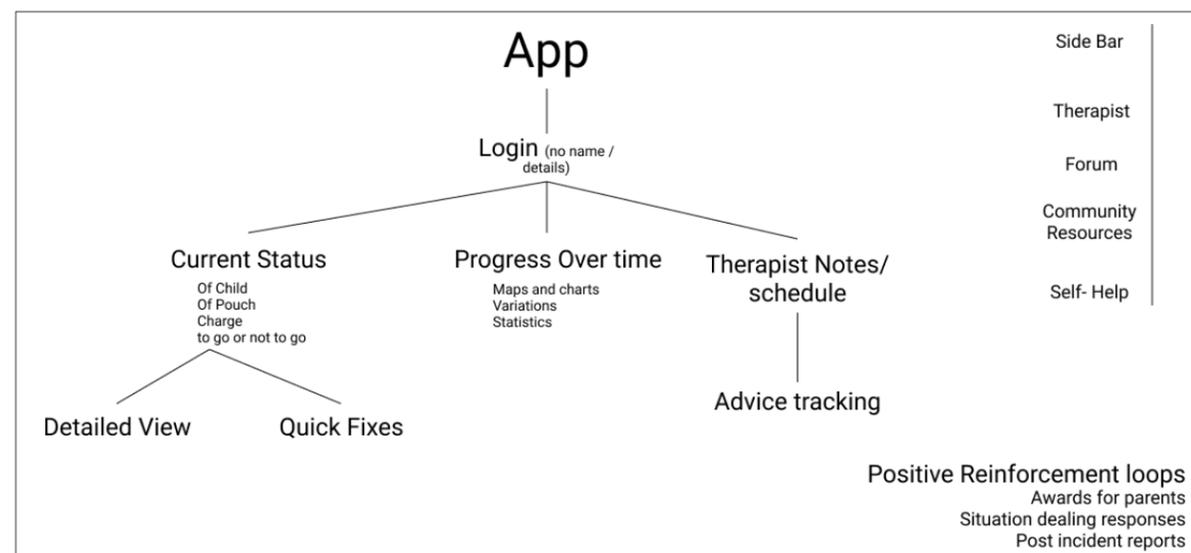


Figure 6.2.1: The App breakdown



Figure 6.2.2: Version 1 of the app

The Bouba-Kiki effect<sup>38</sup> has been long studied by psychologists and employed in various fields, especially when designing for effective and efficient communication.<sup>39</sup> The theory suggests that rounded shapes are perceived as calming and inviting, whereas sharper shapes are considered to be energetic and dynamic. Using these under-lying principles, and taking from research<sup>40</sup> in this field and visual language was developed taking the Visualized Emotion Ontology chart (Fig 6.2.3) as a source of inspiration.

38 Torø Graven and Clea Desebrock, "Bouba or Kiki with and without Vision: Shape-Audio Regularities and Mental Images," *Acta Psychologica* 188 (2018): pp. 200-212, <https://doi.org/10.1016/j.actpsy.2018.05.011>.

39 Zeynep Lokmanoglu, "The Bouba-Kiki Effect on Branding: How Sound Symbolism Shapes Design," *99designs* (99designs, September 22, 2021), <https://99designs.com/blog/design-history-movements/bouba-kiki-effect-exploring-links-sound-symbolism-design/>.

40 Rebecca Lin et al., "Visualized Emotion Ontology: A Model for Representing Visual Cues of Emotions," *BMC Medical Informatics and Decision Making* 18, no. S2 (2018), <https://doi.org/10.1186/s12911-018-0634-6>.

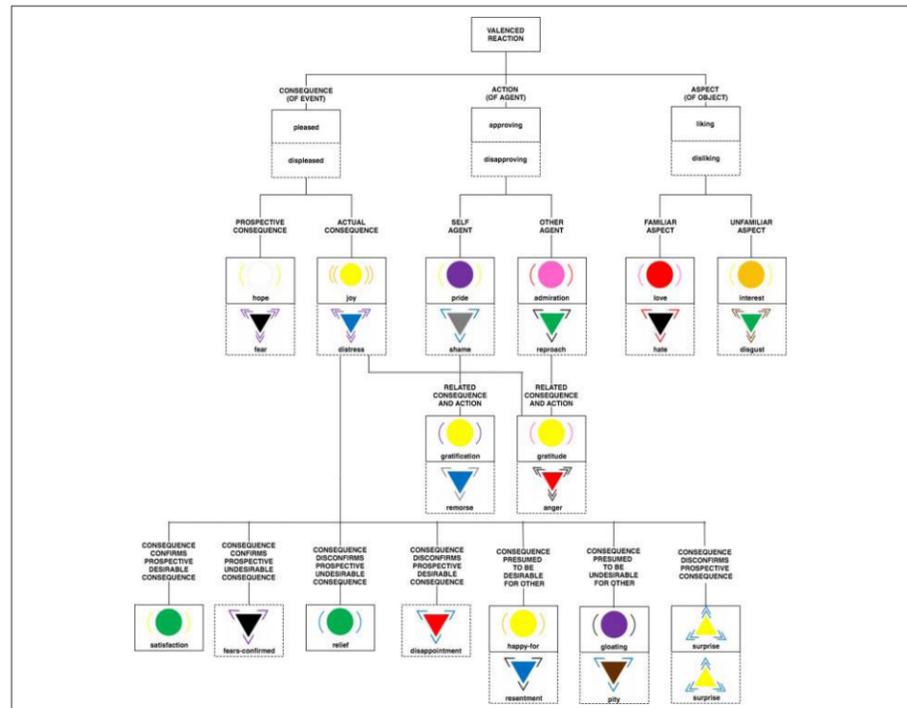


Figure 6.2.3: Shapes and Emotions

Color is an important part of our lives and according to WGSN's Advanced Color Forecast 2025<sup>41</sup>, color will play a key role in experiences on-line and in real life. With translucencies and overlaying of elements, an immersive experience along with interactions is slated for the future. The user interface and experience will attempt to employ these learnings through the design of this app.

The visual language studies combined with cultural understanding of emotions led to the creation of the chart visuals (Fig 6.2.4), which were then translated into an app design (Fig 6.2.5) and underwent revisions (Fig 6.2.6) based off inputs from parent and therapists.

41 Jenny Clark, "Advanced Colour Forecast 2025," WGSN, accessed March 31, 2022, <https://www.wgsn.com/beauty/p/article/88678>.



Figure 6.2.4: Emotions as shapes and colors

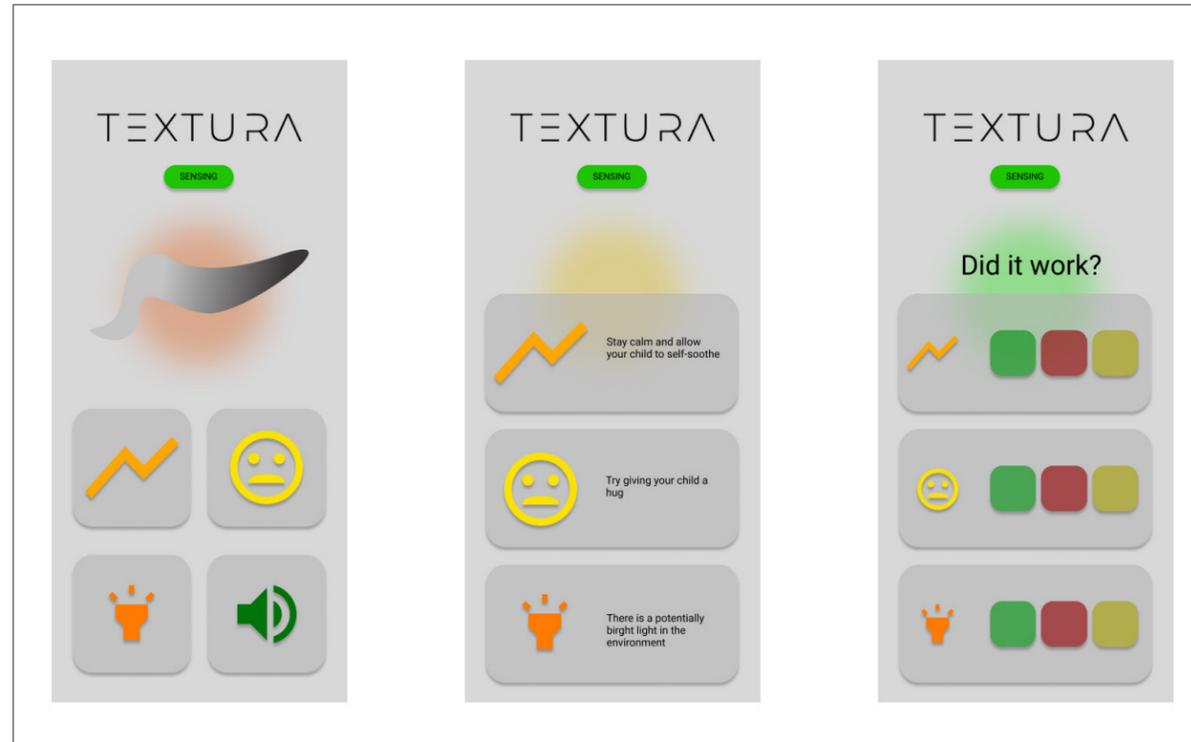


Figure 6.2.5: Version 2 of the app

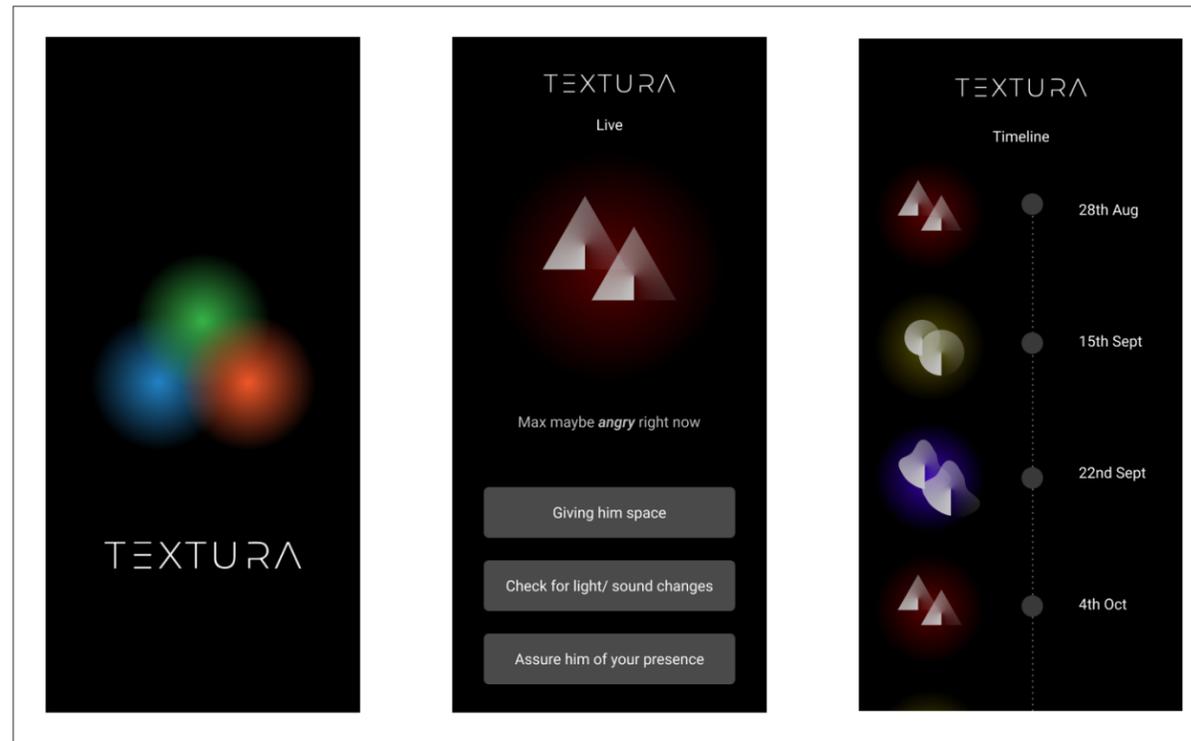


Figure 6.2.6: Version 3 of the app

### 6.3. Materiality



Figure 6.3.1: Material Board

Research<sup>42</sup>, observational analysis from past experience and talking to professionals has shown that materials and textures may be beneficial to this project. The tactile stimulus apportioned to an individual with ASD can be beneficial or detrimental to their emotional state. In all interviews it was found that children with ASD either had a comfort fabric or a textural experience they relished. Be it the spiky texture of hard bristles, or softness of velvet or even the curves on a belt buckle, each child has their own flavor. This makes the materiality of the product an essential consideration.

Through the interviews and first-hand experience of the stakeholders, a series of tactile experiences were chosen (Fig 6.3.3) keeping in mind the differences in textures and the feel of such fabrics. Upon further inquiry through interviews, a common affinity towards soft and smooth textures was discovered, making short-pile fabrics a favorite amongst many children. Yet the issue of personalized textures and how a child with ASD might respond to them, remains.

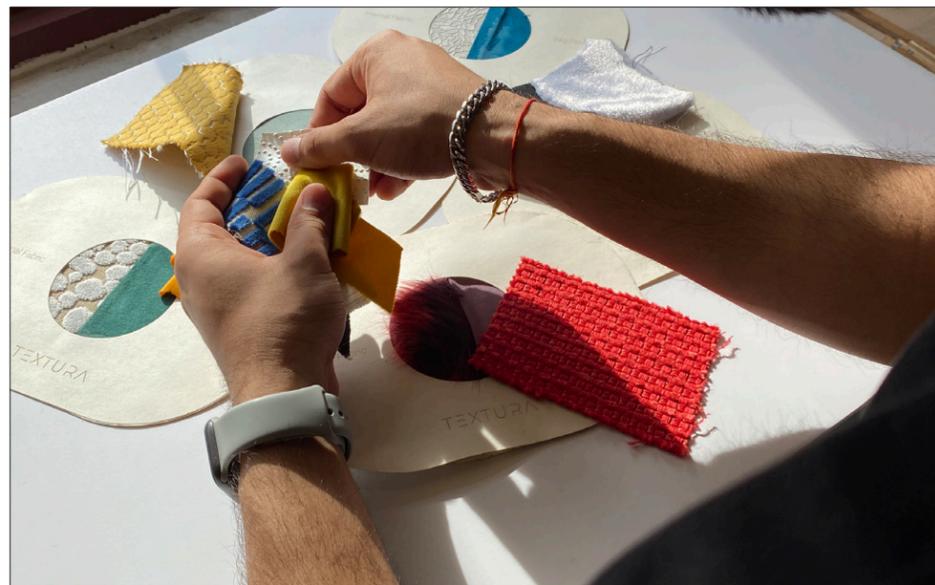


Figure 6.3.2: Selecting the textures



Figure 6.3.3: The chosen bag and interior textures

42 Farahiyah Wan Yunus et al., "Sensory-Based Intervention for Children with Behavioral Problems: A Systematic Review," *Journal of Autism and Developmental Disorders* 45, no. 11 (2015): pp. 3565-3579, <https://doi.org/10.1007/s10803-015-2503-9>.

## 6.4. Iterative Process

Through feedback and check-ins with stakeholders the chosen direction of a pouch underwent various alterations and improvements.

### 6.4.1 The Outside

Taking into account how autistic children tend to have a comfort fabric on their person, the concept of a pouch was taken ahead. Since the concept introduces a new product to a child's existing environment, design was dictated by what children in the target age of 5-8 years would respond positively to. For this reason, a landscape survey (Fig. 6.4.1.1) on bags and pouches was conducted.

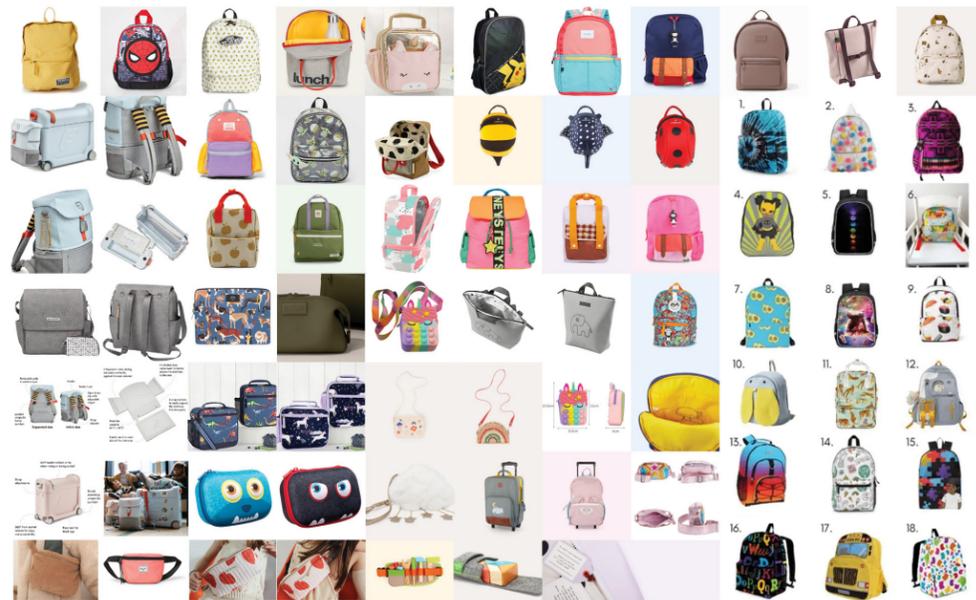


Figure 6.4.1.1: Bags and pouches used by the target age group

The landscape survey was useful to define the colors, figures and details on a pouch for the target age group. The patterns emerging from this (Fig 6.4.1.2) opened avenues to explore various shapes and forms for potential pouches.

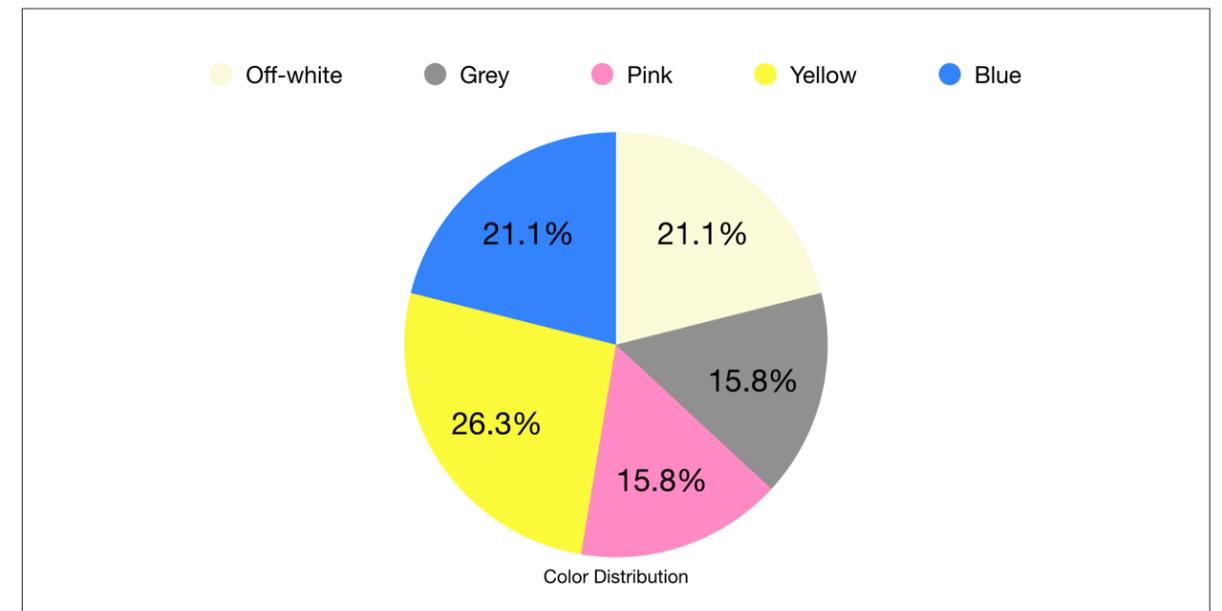
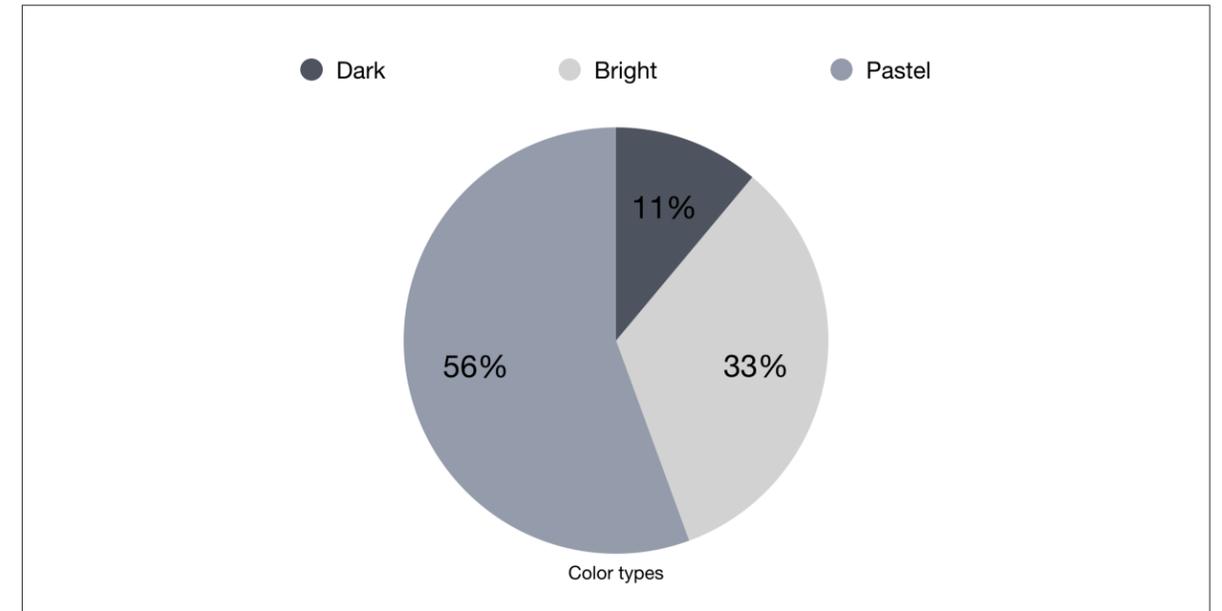


Figure 6.4.1.1: Analysis of landscape surveys (contd.)

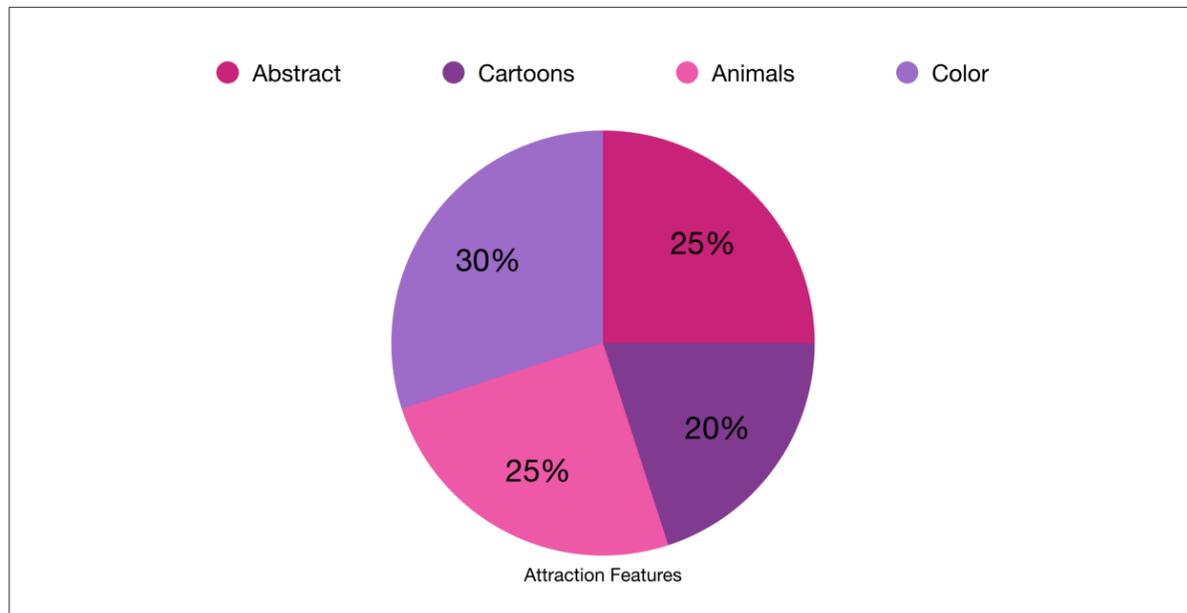
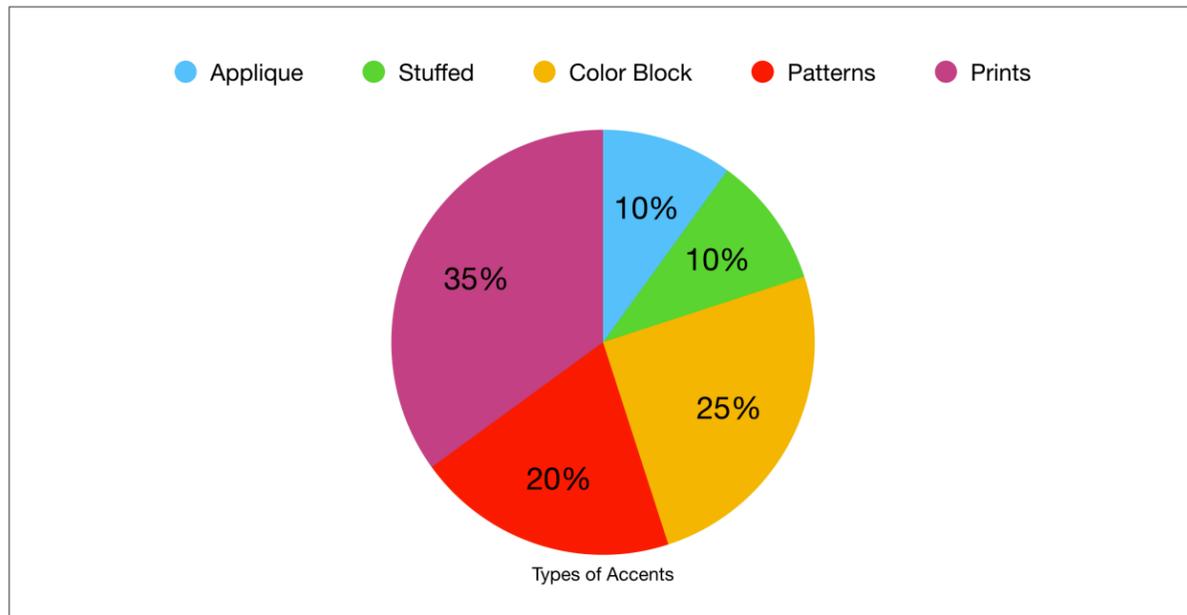


Figure 6.4.1: Analysis of landscape surveys (contd.)

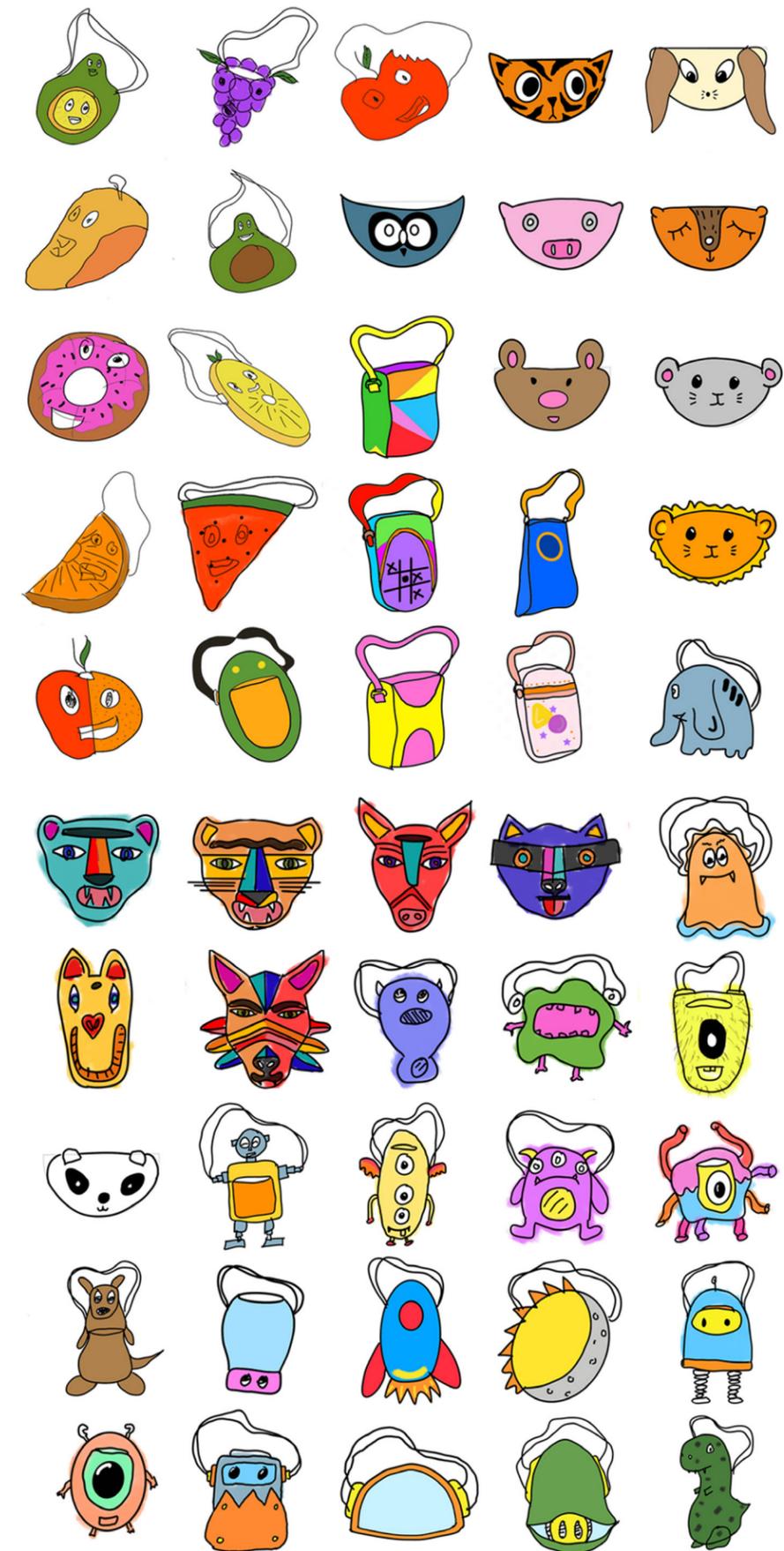


Figure 6.4.2: Sketches for potential pouches

Building off the analysis of the landscape survey, 4 different categories were chosen to sketch and make options for different pouch types.

### Sketch categories

- Animals
- Fantastical Beasts
- Fruits and Vegetables
- Color Blocking

Through sketches (Fig 6.4.1.2) and feedback sessions, 4 designs were chosen to develop and test with children of the target age group.

## 6.4.2 The Inside

The inside of the pouch has two major components, i.e. the tactile experience to keep the child engaged over time and the glove. The tactile experiences (*chosen in Section 6.3: Materiality*) were cut into 2x2 inch squares to be stitched along the inner wall of the pouch. The glove, which houses the technology was selected from an array (Fig 6.4.2.1) of cut styles and material explorations. The internal glove (Fig 6.4.9) was designed through anthropometric data of the target age group and made ambidextrous, keeping in mind that the pouch could be slung on either shoulder.

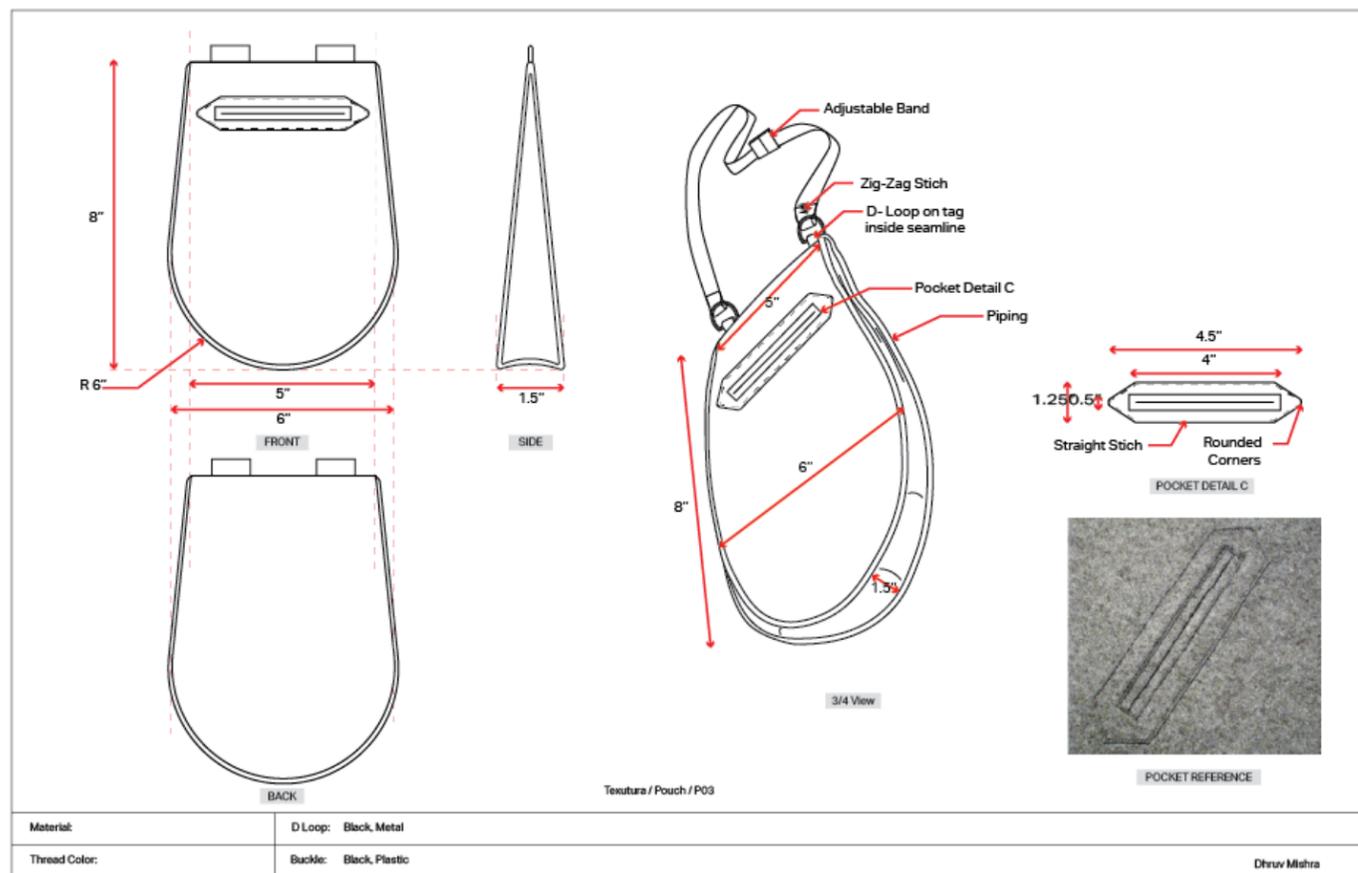


Figure 6.4.1.3: A technical drawing of one of the chosen pouches

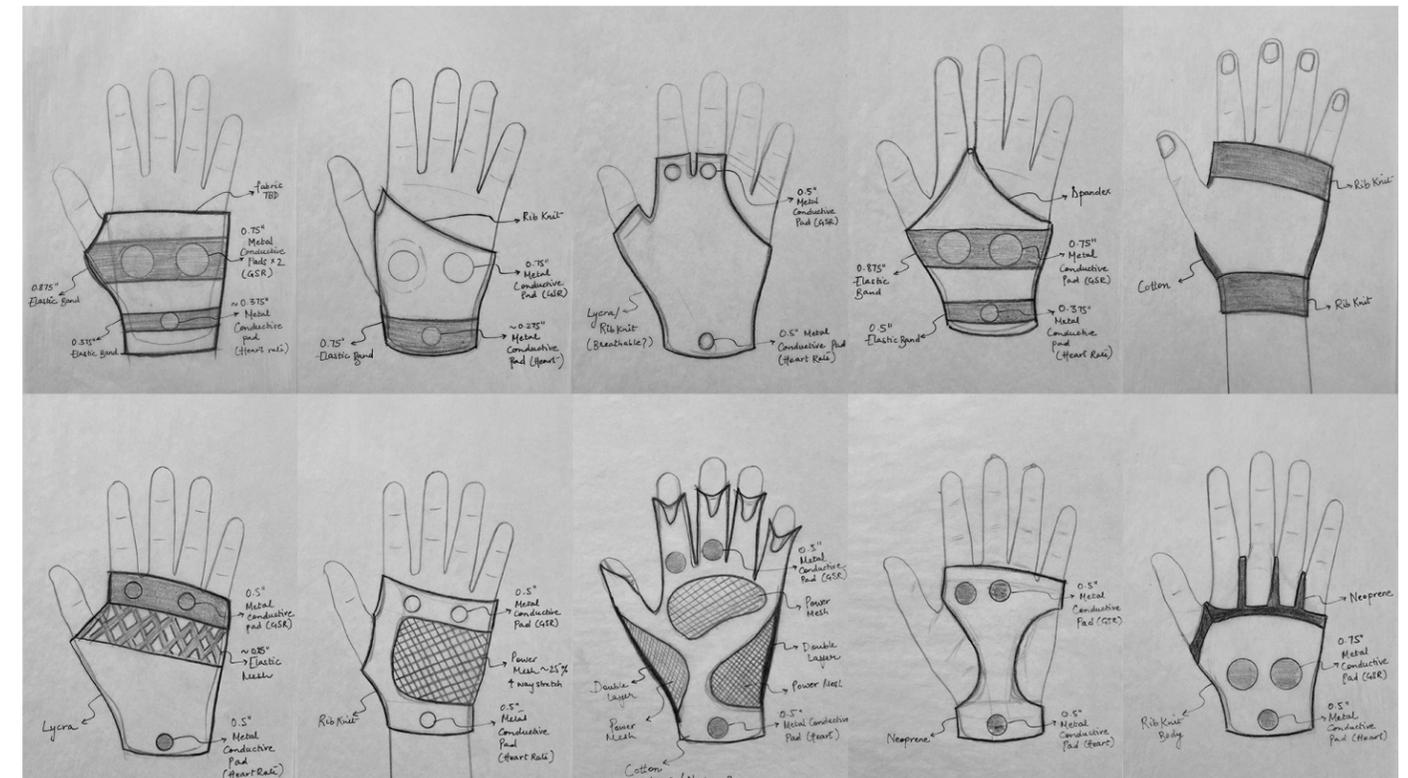


Figure 6.4.2.1: Glove options considered

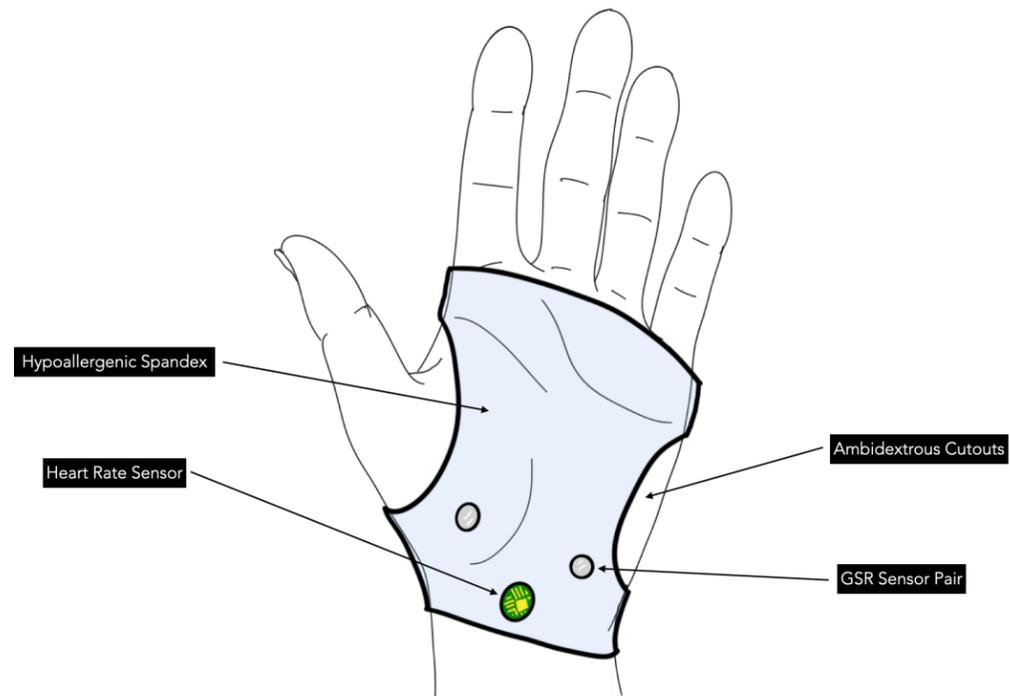


Figure 6.4.2.2: The chosen glove

The glove from Fig 6.4.2.2, designed through anthropometric data of the target age group was chosen as the final as it could be used ambidextrously (*the pouch could be slung on either shoulder*) which giving enough space to house the technology, whilst being breathable enough for extended durations of time.



### 6.4.3 The Technology

The technology is embedded into the glove with flat flexible lines transferring data and power to and from a logic board in the top side of the pouch.

The sensors include

- One pair of **Galvanic Skin response** sensors
- One **Heart Rate Monitor**

So as the child interacts with the textures inside the pouch (Fig 6.4.3.2), the sensors track and log data (Fig 6.4.3.4). This data is then run through an on-board program which is then translated into emotional states on the parent's end.

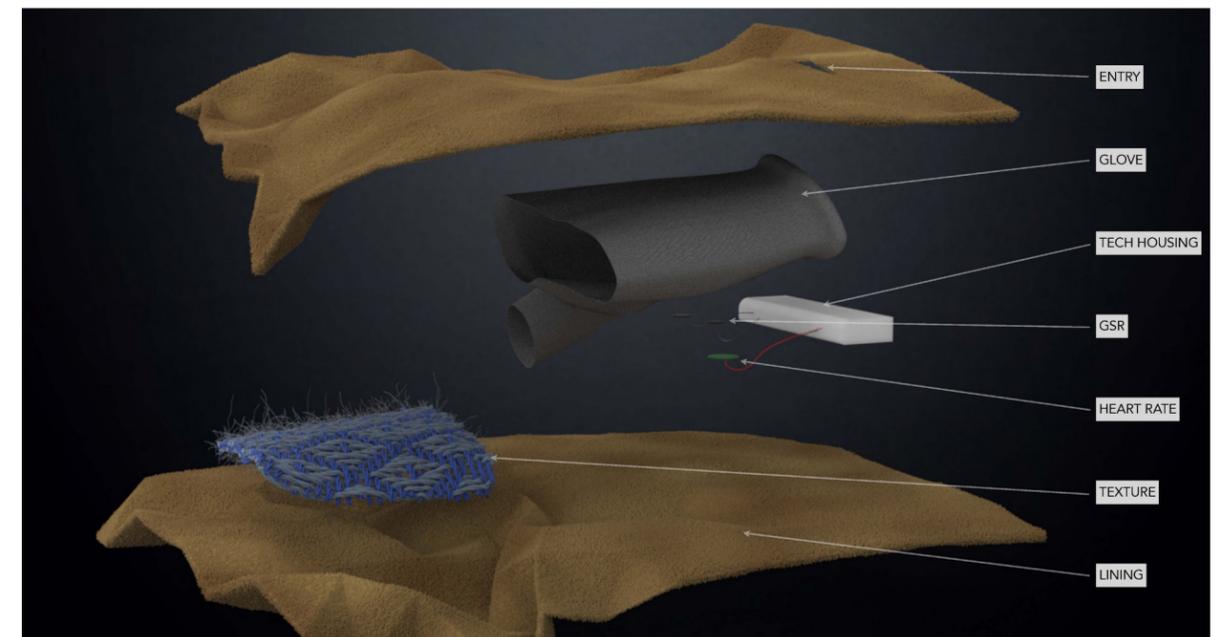


Figure 6.4.3.1: Breakdown of the pouch internals



Figure 6.4.3.2: Textures inside the pouch

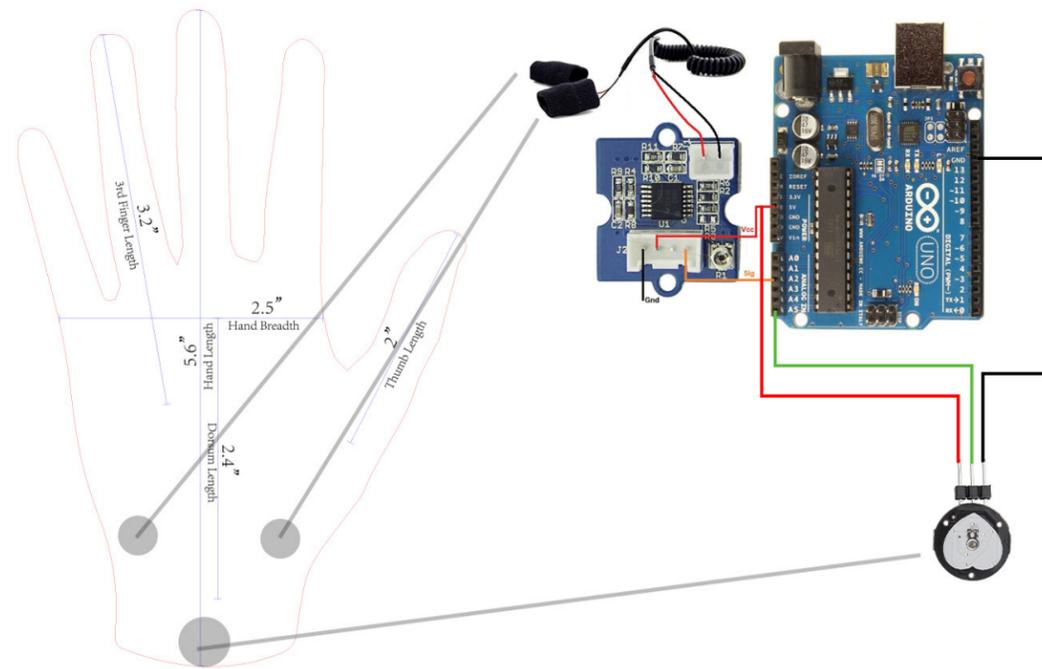


Figure 6.4.3.3: Circuitry and placement

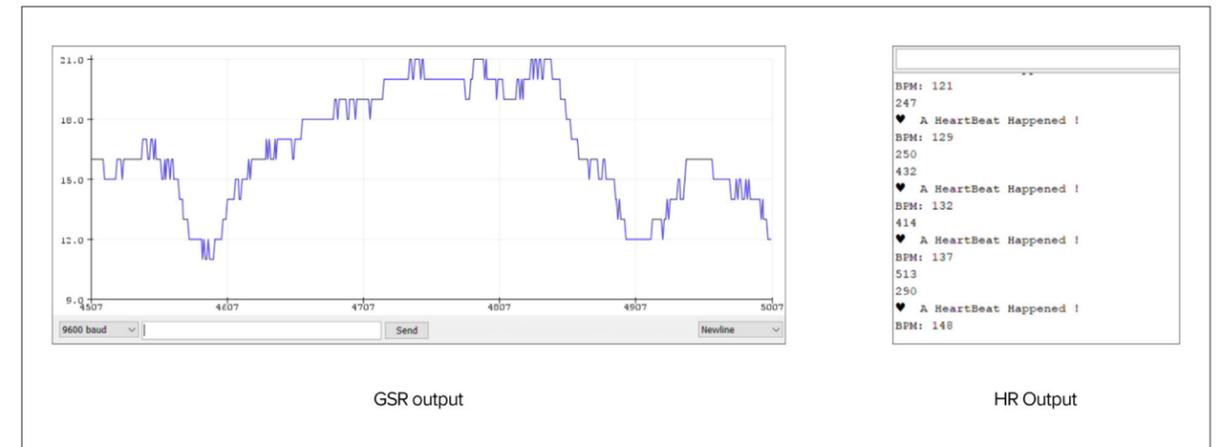


Figure 6.4.3.4: Data captured from the sensors embedded in the glove

The GSR translates differences in skin conductances into a live chart of valleys and peaks. Once cross-referenced with the heart rate at the same time, the two datasets combine to provide an estimation of emotional data.

	Type	Measures	Compatibility with textile	Issues
	Galvanic Skin Response	Conductance of skin via change in electric conductance	Yes	Needs to be worn at all times to give a better result
	Heart Rate	HR	Yes	Needs a few seconds to give proper data (not instant)
	RGB Motion detection	Movement of objects	Yes	Needs a single subject, lights can deteriorate data, needs long and comprehensive algorithm

Figure 6.4.3.4: Sensor Compatibility

## 6.5. Testing

### 6.5.1 With Children

The testing of this product was conducted with 4 neurotypical children in the age range of 5-8 years as access to autistic children was not possible at the time. The parameters from *Fig 6.5.1.1* were used to understand how each pouch performed in a qualitative and quantitative way.

The test subjects responded positively to the form and characters of the pouches and were engaged deeply in interacting with the internal fabrics over a period of 1 hour. The *Octopi Guy* was an instant attraction for children due to its colorful and intriguing appearance. Whereas, the internal tactile experience inside *Mr.Robot* was more “satisfying” and “fun to touch” for the test subjects.



Fig 6.5.1.2 Test prototypes

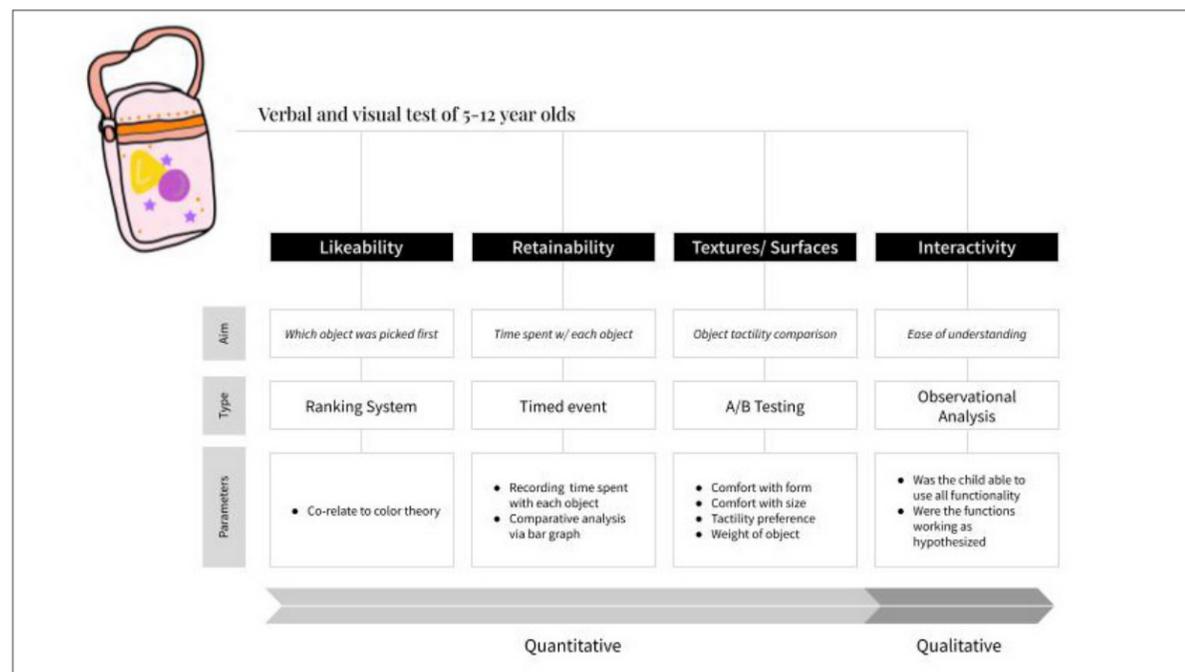


Fig 6.5.1.1 The parameters of the test



Fig 6.5.1.3 Testing with Child 1



Fig 6.5.1.4 Testing with Child 3

## 6.5.2 With Parents and Therapists

Done over zoom and in-person meetings, testing for the app with the parents of children with ASD, was based off parameter from Fig 6.5.2.1. Questions were asked to form a cost-benefit analysis and understand loopholes in the app.

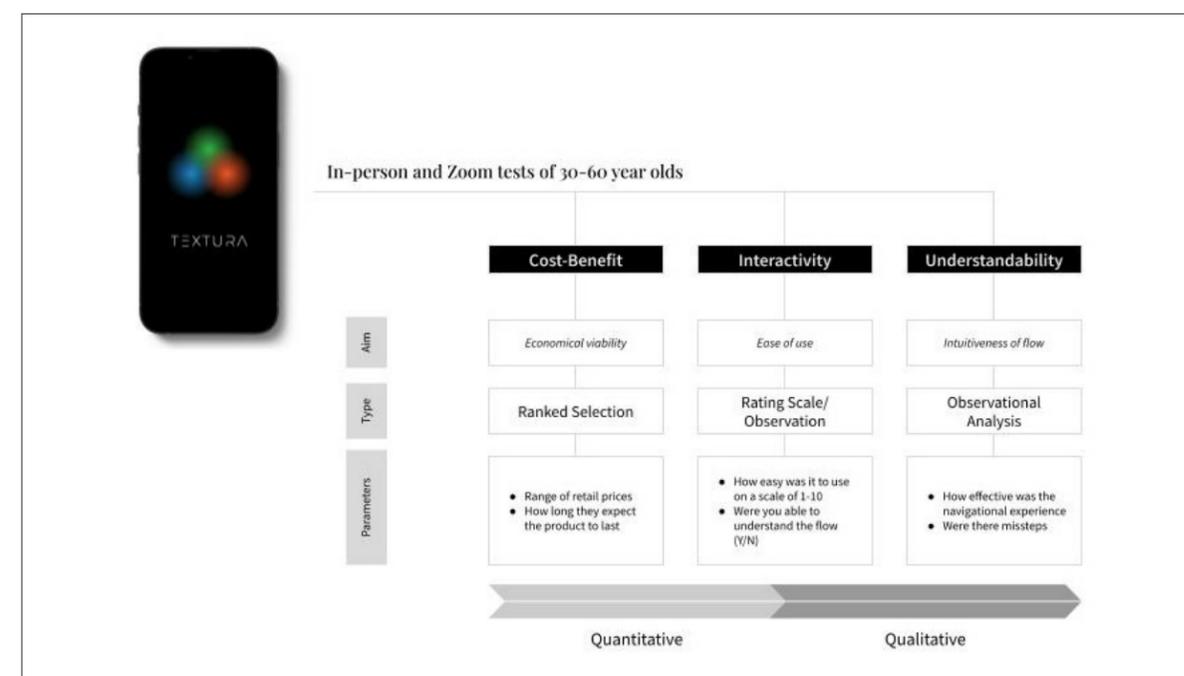


Fig 6.5.2.1 The parameters of the test

Parents mentioned that, “such a device would have been beneficial for them to better understand... (Their child)” and how “Cost would not be barrier” asked about a suitable price range for such a product to lie in. On the topic of the app, one parent felt like, “it made life simpler by giving them (me) solutions at on their (my) fingertips”, while another pointed out that, “the shapes to emotions conversion had (has) a learning curve... a cheat sheet for that would be helpful.”

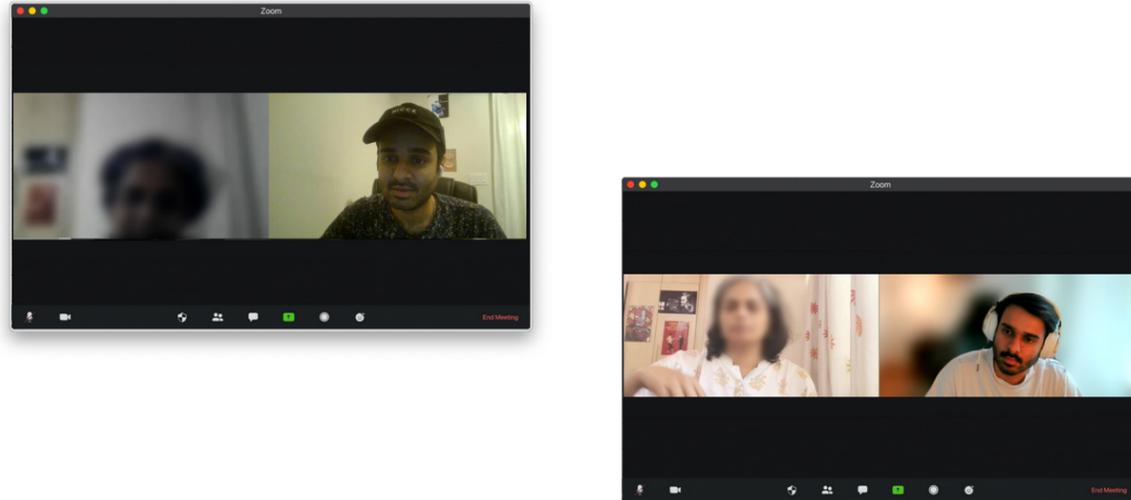


Fig 6.5.2.2 Tests with parents

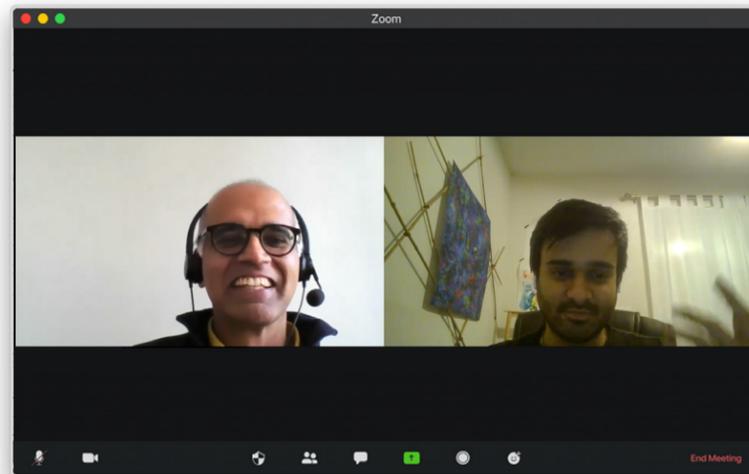


Fig 6.5.2.3 Tests with a therapist

## 6.7. Takeaways and Updates

The testing helped bring to light that neurotypical children would want such a product as that when paired with the right tactile experience, even autistic children would take a likeness to it. The size of the pouches were optimal, but the entry point for the pouch could take other sizes to accommodate for a larger hand. The attachment points could be varied as some children preferred slings while other indicated a desire to, “hook it onto their (my) belt loop over even use it as a belt.”

To improve upon these findings, two more pouches were created and existing ones were altered. The textures were made more obvious and attachment styles were added in various places to allow the user to wear them as preferred.

On the app end for the parents, a clearer flow of content was seen as a need, as well as a simpler UI. Parents felt like the information should be, “easy to read” and “quick to draw from...”

To make the emotions clearer, an overlay of color was added to the shapes that would correspond to existing schools of thought about emotions as colors<sup>43</sup>. A timeline option was added after consultation with a child-therapist. This was done to provide therapists emotional data over time and see it in a linear path to make deductions of emotions over time easier to read and provide solutions for.

43 Domicile Jonauskaite et al., “Feeling Blue or Seeing Red? Similar Patterns of Emotion Associations with Colour Patches and Colour Terms,” *i-Perception* 11, no. 1 (2020): p. 204166952090248, <https://doi.org/10.1177/2041669520902484>.

# Chapter 7: Final Prototype



The final prototype for this thesis came in the form of 4 pouches, with a companion app and the ideology of an ecosystem that would benefit the 3 units of the tripartite juncture. The pouches come with different attachment styles, i.e. belts, hooks or slings to be worn in different areas of the body.

The app for parents and therapists follows the language from earlier iterations with tweaks to the flow of the UI and changes to 'translation' of emotions to make them more understandable.



Figure 71: Octopi Guy



Figure 71: Octopi Guy



Fig 7.2: Mr. Robot



Figure 7.3: Rocket and Buttons

# Chapter 8: Future Opportunities

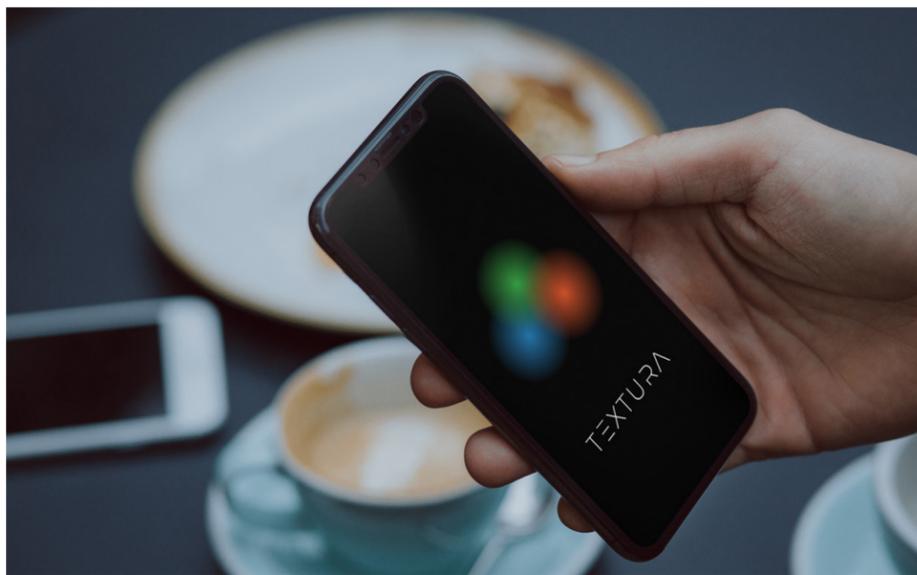
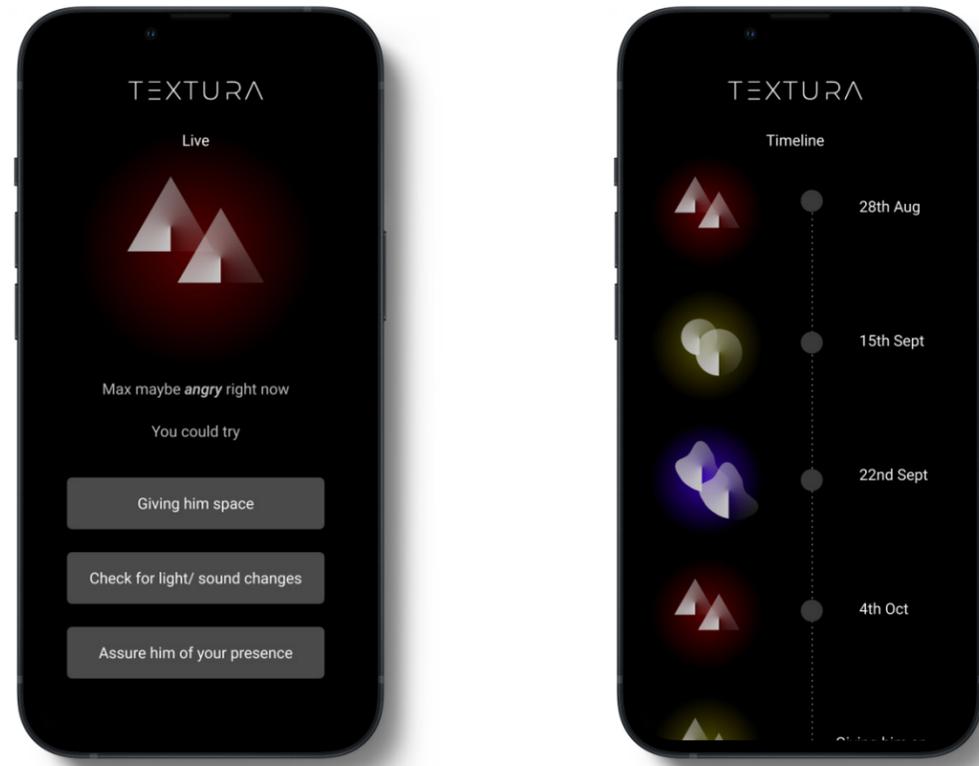


Figure 7.2: The Textura app for parents and therapists

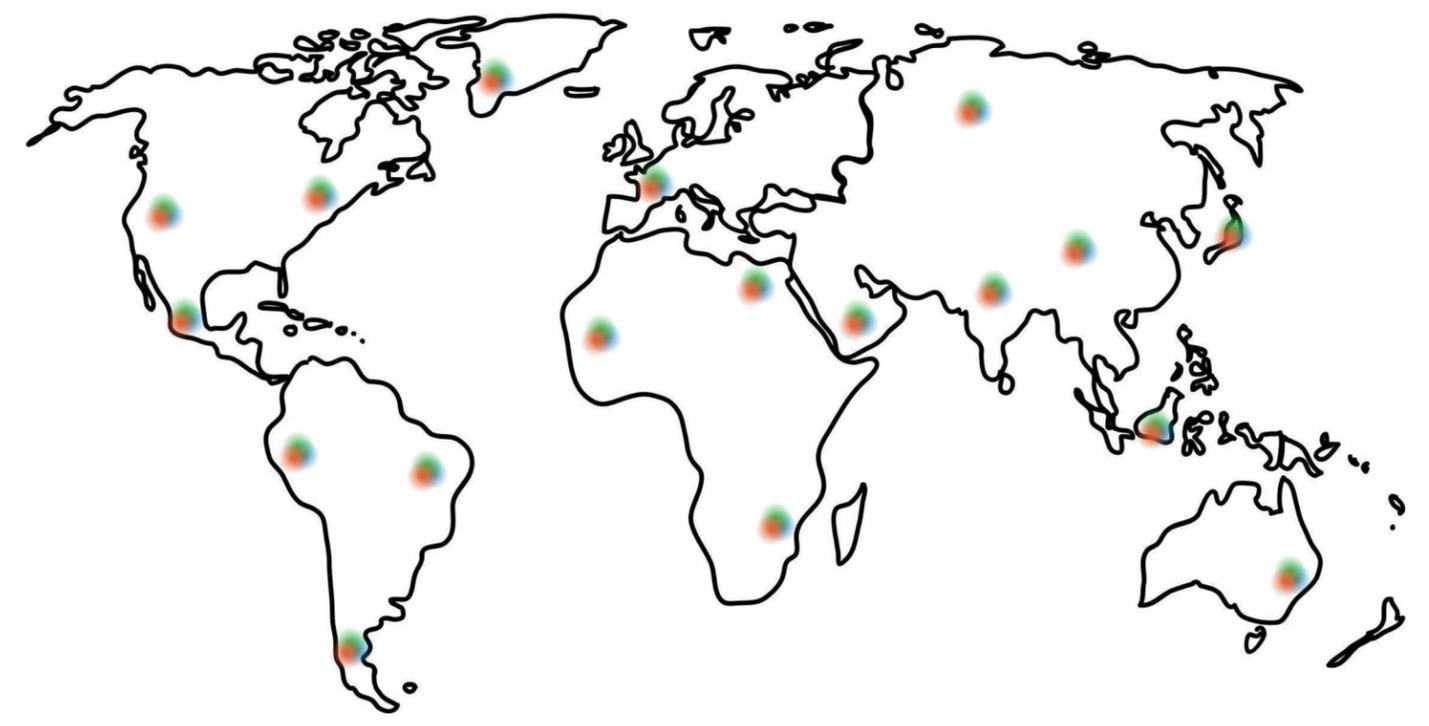


Fig 8.1: Textura can help millions around the globe

## Global Reach

The Textura system can grow in a variety of ways including, but not limited to connecting parents and therapists from across the globe (Fig 8.1). As the system learns and grows with other experiences and solutions, this could potentially give better and more meaningful solutions to all. The GAN can learn from different experiences and build overarching baselines for all members of the tripartite unit. It is true that each child, family and therapeutic intervention is unique in their own way, but the Textura system could prove beneficial in creating datasets and furthering knowledge on ASD.

## Safe Space

Another aspect that was mentioned in interviews, was the need of a safe space to vent and get assurances from fellow parents of autistic children. Hence, making this ecosystem a safe space to do so would be beneficial to many parents. For the future, anonymous/ pseudonymous accounts could be created by parents to allow for exchange of thoughts, ideas or feelings. Since caring for a child with ASD may have an effect on one's mental health, such communities might help the parents mentally, whilst opening avenues to multiple possibilities of alternate care or methods.

## Alternate Uses

Since the sensors inside can be easily replaced, this system can be used to log and track various physiological changes as well. The same pouches with body temperature, oxygen levels, etc could be deployed in refugee camps to monitor/ screen children for health issues. This could also herald a change in how medical devices are made for children in general, to make the child enjoy the experience instead of being fearful.

# Conclusion

The bond between a parent and child is a unique and precious one. It is equally important for both to be able to communicate and understand one-another. Helping bridge that gap has been an interesting and fruitful process for me. Alongside this, I was able to take a deeper dive into the world of medical design for inclusion and accessibility which remains my area of interest since my undergraduate thesis. Working with an entirely new field of soft-goods too helped me grow and expand my horizons in the vast field of design.

While this study was conducted in a structured and impartial manner, there is always room for improvement. Accepting that each child is unique and the nonavailability of a baseline for child with ASD helped advance this thesis in directions that would not have been possible otherwise. The lack of data available and stringent laws made access to children tough to achieve, however with more resources and time such issues might be overcome, to create a more robust result.

Furthermore, as this study was conducted through a limited set of parents, therapists and educators over a short period of time, adding more inputs from a variety of socio-economic and cultural differences would greatly benefit the applicability of the solution.

Overall, this year long experience has helped me learn and grow whilst increasing confidence in my skills as a designer and preparing me for my next steps towards designing for inclusion.

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# Appendix I

## CONSENT TO PARTICIPATE IN RESEARCH STUDY



Designing for Communication between  
individuals with Autism and their caregivers

Consent to take part in research

Name of Principal Investigator: Dhruv Mishra  
Name of Organization: Pratt Institute  
Name of Project and Version: Textura

This Informed Consent Form has two parts:

- Information Sheet (to share information about the study with you)
- Certificate of Consent (for signatures if you choose to participate)

You will be given a copy of the full Informed Consent Form

### **Part I: Information Sheet**

#### **Introduction**

I am Dhruv Mishra, a graduate student at Pratt Institute. I am doing research on communication between individuals with autism and their caregivers. I am going to give you information and invite you to be part of this research. You do not have to decide today whether or not you will participate in the research. Before you decide, you can talk to anyone you feel comfortable with about the research.

#### **Purpose of the research**

Currently, communication with individuals with autism is a one-way street, wherein such individuals have to understand what their caregivers are trying to say to them. I believe that you can help me identify current communication strategies at home and give me insights on gaps in communication that would help new parents better understand their children. I also want to know what type of products/ strategies you would recommend from your experience.

#### **Type of Research Intervention**

This research will involve qualitative interviews and surveys paired with user- centered design strategies. These interviews can last from between 30-90 minutes depending on your availability.

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**Participant Selection**

You are being invited to take part in this research because I feel that your experience as a parent of an individual diagnosed with autism can contribute much to my understanding and knowledge of possible solutions.

**Voluntary Participation**

Your participation in this research is entirely voluntary. It is your choice whether to participate or not. The choice that you make will have no bearing on your job or on any work-related evaluations or reports. You may change your mind later and stop participating even if you agreed earlier.

**Procedures**

If you accept, you will be asked to participate in interviews in-person or on Zoom (depending on your choice).

During the interview, I will sit down with you in a comfortable place of your choosing. If you do not wish to answer any of the questions during the interview, you may say so and the interviewer will move on to the next question. No one else but the interviewer will be present unless you would like someone else to be there. The information recorded is confidential, and no one else except [Dhruv Mishra] will have access to the information documented during your interview. The entire interview will be audio-video recorded. The recording will be kept on a harddrive. The tapes will be destroyed after approval of the thesis.

You may also be asked to participate in surveys.

Fill out a survey which will be provided and collected by Dhruv Mishra OR You may answer the questionnaire yourself, or it can be read to you and you can say out loud the answer you want me to write down.

If you do not wish to answer any of the questions included in the survey, you may skip them and move on to the next question. This will be an online survey through Google Forms. The information recorded is confidential, your name is not being included on the forms, only a number will identify you, and no one else except Dhruv Mishra will have access to your survey.

**Duration**

This research will take place over 60 days, during which I will conduct interviews and surveys 2 times a month lasting between 30-90 minutes.

**Risks**

The presence of the interviewer may be detrimental to ongoing therapy and cause stress to the

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interviewee. It could cause awkwardness and grief.

**Benefits**

There will be no direct benefit to you, but your participation is likely to help us find out more about where communication currently stands and your insights could help build a more holistic experience for future parents with children on the spectrum.

**Reimbursements**

You will not be provided any incentive to take part in the research.

**Confidentiality**

The research being done in the community may draw attention and if you participate you may be asked questions by other people in the community. I will not be sharing information about you to anyone outside of Pratt Institute's Industrial Design Department. The information that we collect from this research project will be kept private (or anonymous if selected in the consent form below).

**Sharing the Results**

Nothing that you tell us will be shared with anybody outside the research team, and nothing will be attributed to you by name(if requested). The knowledge that we get from this research will be shared with you before it is made widely available to the public. Each participant will receive a summary of the results.

**Right to Refuse or Withdraw**

This is a reconfirmation that participation is voluntary and includes the right to withdraw.

You do not have to take part in this research if you do not wish to do so, and choosing to participate will not affect the study. You may stop participating in the [discussion/interview] at any time that you wish without the study being affected. I will give you an opportunity at the end of the interview/discussion to review your remarks, and you can ask to modify or remove portions of those, if you do not agree with my notes or if I did not understand you correctly.

**Who to Contact**

If you have any questions, you can ask them now or later. If you wish to ask questions later, you may contact any of the following:

Dhruv Mishra  
[dmishra@pratt.edu](mailto:dmishra@pratt.edu)  
+1 (518) 605 6019

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This proposal has been reviewed and approved by Pratt Research and Strategic Partnerships , which is a committee whose task it is to make sure that research participants are protected from harm. If you wish to find out more about the IRB, contact Katheryn Kelly at kkelly17@pratt.edu

You can ask me any more questions about any part of the research study, if you wish to. Do you have any questions?

**Part II: Certificate of Consent**

- I \_\_\_\_\_ voluntarily agree to participate in this research study.
- I understand that even if I agree to participate now, I can withdraw at any time or refuse to answer any question without any consequences of any kind.
- I understand that I can withdraw permission to use data from my interview within two weeks after the interview, in which case the material will be deleted.
- I have had the purpose and nature of the study explained to me and I have had the opportunity to ask questions about the study.
- I understand that participation involves interviews and/or surveys.
- I understand that I will not benefit directly from participating in this research.
- I agree to my interview being audio and/or video-recorded.

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- I understand that all information I provide for this study will be treated confidentially.
- I understand that (if selected), in any report on the results of this research my identity will remain anonymous. This will be done by changing my name and disguising any details of my interview which may reveal my identity or the identity of people I speak about.  
 Tick this box to confirm anonymity
- I understand that extracts from my interview may be quoted in presentations and theses at Pratt Institute.
- I understand that if I inform the researcher that myself or someone else is at risk of harm they may have to report this to the relevant authorities - they will discuss this with me first but may be required to report with or without my permission.
- I understand that signed consent forms and original audio and/or video recordings will be retained on a harddrive with access only to Dhruv Mishra until approval of the thesis by Pratt Institute.
- I understand that under freedom of information legalization I am entitled to access the information I have provided at any time while it is in storage as specified above.

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- I understand that I am free to contact any of the people involved in the research to seek further clarification and information. Names, degrees, affiliations and contact details of researchers (and academic supervisors when relevant).

Signature of research participant \_\_\_\_\_

Date \_\_\_\_\_

I believe the participant is giving informed consent to participate in this study

Signature of researcher \_\_\_\_\_

Date \_\_\_\_\_

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