Smart Adaptive Mentor [S.A.M.]

INTERVENTIONS WITH MACHINE LEARNING TO SUPPORT UNIVERSITY STUDENTS WITH HIGH FUNCTIONING AUTISM

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Abstract

Many academically proficient students with autism pursue higher education in universities. Unfortunately, there is a substantial difference in the enrollment and graduation rates of this student population. The focus on grades often inhibits people from recognizing other factors that affect academic advancement. The sudden deprivation of support "systems" students were accustomed to, leaves them at a disadvantage. This loss presents a promising opportunity for design intervention — using design methodologies and technological advancement to support the complex needs of the disorder. This research investigates how integrating Machine Learning into smart devices can create a unique and accessible intervention providing timely support.

PROBLEM DEFINITION

Introduction

Being independent in university brings with it certain responsibilities, decorum, and rules that vary depending on a culture's definition of what it means to be an independent adult. Identifying and working within these constraints can be arduous. These issues become more pronounced for university students with Autism Spectrum Disorder (ASD). For university students with ASD, executive function deficits intensify the difficulty of identifying and performing tasks within these constraints (Ozonoff et al. 1991). ASD manifests itself in diverse ways and across a 'spectrum.' For example, one person may have heightened memory and attention yet have low cognitive flexibility making planning and adjusting to changes significantly harder. Variations in communication skills especially at a tacit level of understanding context-specific rules make it difficult to interpret the unspoken rules of being an adult. For instance, some might not realize they are talking more than is comfortable or "culturally normal."

Autism Spectrum Disorder: Neurodevelopmental disorder that affects an individual's social and communication skills and is characterized by repetitive or restrictive behavior (American Psychiatric Association, 2013).

At the age of 18, many university students with ASD lose access to support programs, such as the Individualized Education Program (IEP) for special education, which they received while in high school. Losing access to such support while pursuing a more rigorous academic career can be stressful, therefore ASD students may stand at a disadvantage for functioning within the current university experience. On entering university, students with ASD encounter diverse challenges. Measures for the support of students, such as extended submission deadlines, extra test time, and a separate room for tests are available at many universities. These accommodations, though, do not aid with challenges such as planning schedules or time management or daily life activities outside the bounds of academic study, etc.

Neurotypical: A person not affected with a developmental disorder, especially autism spectrum disorder (Merriam-Webster, n.d.).

The current options to support students with autism, do not address the unique needs of the students. It, therefore, becomes important to investigate this problem space to empower students on the spectrum to compete on par with neurotypicals. As designers, we can empathize and work with our users to create a better experience and advocate for them. Meeting the requirements of students with ASD is challenging given the complexity and distinctive nature of the disability. Hence collaboration and approaching the topic with a user-centric mindset is key. Combining design methodologies with existing technological growth such as machine learning, we can take advantage of the knowledge and implement an inclusive intervention. The project speculates on this problem space to bring accessible support to students with ASD to augment their college experience. The next first few sections cover the research conducted and orients the reader to the topic of discussion. I justify the need to intervene in the problem space and discuss the limitations of the study. I then give an overview of the literature reviewed for this project. From there I go into my research question and present the design research conducted. With all the information in place, I go over my visual studies and findings. I conclude with the future scope of this problem space and project.

Machine Learning: A subdiscipline of artificial intelligence that builds algorithms that have the ability to learn without explicitly programmed instructions. (Mohr, Zhang, & Schueller, 2017).

Understanding the Situation

What is Autism Spectrum Disorder?

ASD is a neurodevelopmental disorder that affects an individual's social and communication skills and is characterized by repetitive or restrictive behavior (American Psychiatric Association, 2013). This disability affects everyone differently and with varying levels of intensities. People often perceive ASD as a continuum from high- to low- social functioning (as seen in fig 1)- but the case is not as simple.

Figure 1 General ASD perception:
People view ASD as a linear disability. It ranges from less to severe intensity.

The spectrum is a range of different abilities (as seen in fig 2) and the functionality level of those abilities differs for each person. This makes the needs of each individual unique. For instance, 2 High Functioning Autism (HFA) students with a high monotropic mindset will manifest this ability differently. While one student may find it difficult to shift topics during a conversation, the other individual might be hyper focused on one interest that they do not notice much of what happens around them.

Monotropic:
Restricted range of interests. (Murray, Lesser, & Lawson, 2005).

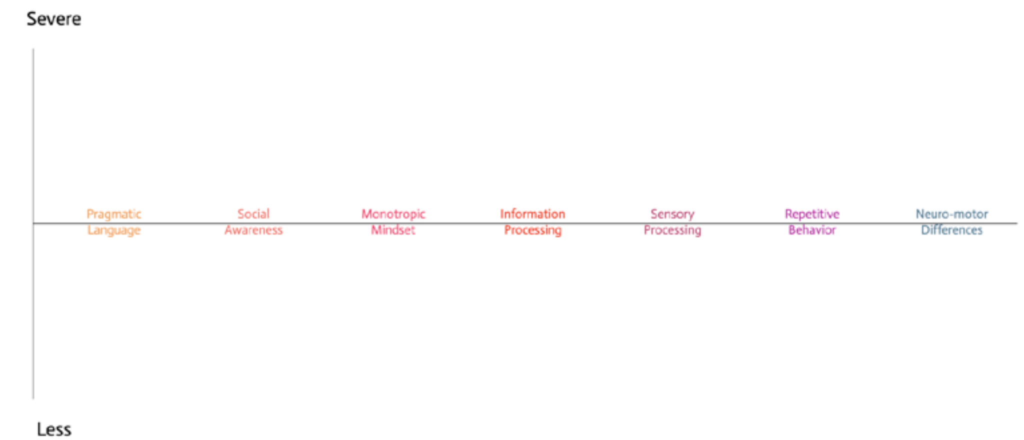

Figure 2 ASD ability graph:
The graph plots the individual's abilities on the X-axis against its level of competency along the Y-axis.

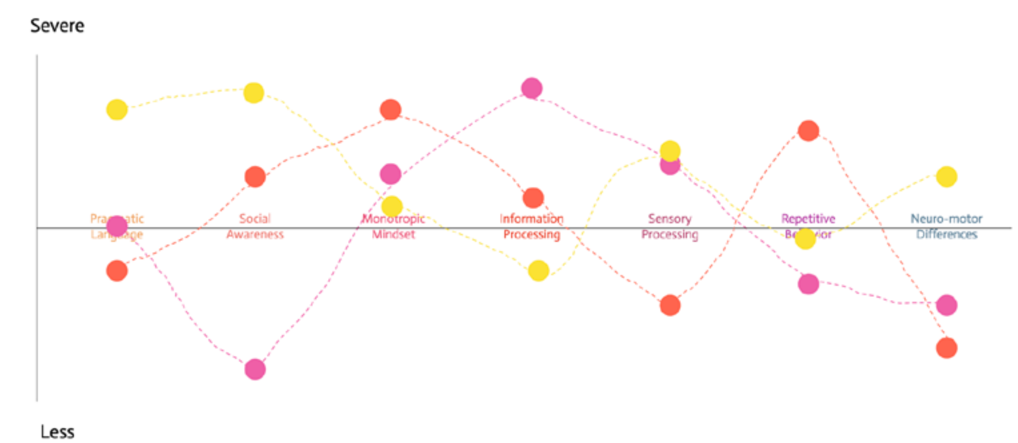

Figure 3 Plotted ASD graph:
The graph plots the functionality level for 3 different individuals with HFA. The orange line maps the abilities of an individual who struggles with sudden changes. The pink line maps the abilities of an individual who struggles with self-care and management. The yellow line maps the abilities of an individual who has trouble with communication and social interaction.

The disability is complex. Professor Stephan Shore who specializes in the field of Special Education and has ASD, states, “If you meet one person with autism, you’ve met one person with autism.” The disorder manifests itself in various repetitive behaviors. I have narrowed down the issue in my design interventions to ritualistic behaviors in HFA where the individual is preoccupied with nonfunctional objects or extreme rigidity of routines (South, Ozonoff, & Mcmahon, 2005).

How Does It Manifest in University Students?

With a combination of legislation (ADA “The Americans with Disabilities Act 1990”) and advocacy (ASA network et al), various kinds of educational opportunities are available to those with ASD. Academically successful HFA students tend to pursue higher education in universities (Barnhill, 2014). There is a significant gap between enrollment and graduation rates in the ASD college community (Cai & Richdale et al., 2015). Support centers in colleges use several strategies to supply academic support. Some of the academic support available are extra test time, but these require the students to disclose their disability. Some students with ASD are reluctant to do so due to the stigma around mental health. They feel that the disclosure of their disability will make them vulnerable to academic or social bias, making them look weak and incapable. They are also worried that the label of “disabled” will become a part of their identity. Additionally, students need to provide sufficient proof of disability before getting access to various support. HFA students do not want to be viewed negatively or be pitied (Bolourian, Zeedyk & Blacher, 2018) by their peers or faculty, which is another concern with disclosing their disability. Those who disclose their disability usually find the support staff useful, but lack of prompt support can cause unfavorable outcomes (Cai & Richdale et al., 2015).

The academic resources offered by the student services do not support the comprehensive needs of students with ASD. It thus becomes important to identify the needs of HFA students in universities and address appropriate ways to support each student even without disclosure. The literature finds several challenges the students face that need support. These include socio-academic demand (e.g., appropriate class behavior) and sensory overload (e.g., students might be unable to filter out multiple stimuli from their environment to concentrate on the lesson) (Hees, Moyson, & Roeyers et al., 2014).

Why is this important?

We are aware of the importance of self-care and being in a positive environment but that can often take a backseat when we get busy with work. Things like not getting enough of sleep or a messy workspace can begin to take a toll on an individual, affecting their overall health. The negative effect on one’s health can affect and lower one’s performance and functioning. Adding further stress to the individual. Ensuring students take care of themselves and get some sleep is not easy but necessary. For neurotypicals, while these tasks can be tedious, the skills and the ability to perform these actions come naturally to them - it is not something they think about. Autists, on the other hand, tend to have disparities in their executive functioning. While some tasks may seem easy to them, certain tasks can be stressful to the point of crippling the individual or causing an autism meltdown.

While there are resources available for those seeking help, the options do not include support for outside of the classroom. There are a plethora of applications and technologies that help people to be productive, but they mostly focus on neurotypicals. Also, these solutions are temporary and do not address the issue in the depth that it should.

One of the more successful support programs is the peer mentoring system. Assigning a trained individual to a student with autism to be their peer mentor. The peer mentor helps the student in making his/her schedule and taking notes. In case the peer mentor is unreachable in the moment of crisis, the problem becomes even more daunting for the student with autism. Also, getting people to take up peer mentor roles is not that easy with the limitations of people and money. Even if parents try to help their child, given the distance, it becomes very limiting.

A critical part of all these interventions includes the students having to disclose their disability. For many, disclosing their disability can seem scary and stressful. Some fear the stigma around mental health or bullying. Others tend to feel guilty about requesting support. In the quest for independence, there are a lot of limitations making the student more dependent and the experience more tedious than it should be.

This creates a promising opportunity for a design intervention. Design of the system will need to focus on the user's distinct needs and adapt solutions to those moments. The design of the system needs to be inclusive and accessible irrespective of the individual disclosing their disability. Creating a seamless approach to getting help, we will be able to control the situation and prevent it from getting worse.

I propose an intelligent peer mentoring system to help share the specific cognitive challenges and experiences outside of the classroom that affects the academic performance of the student, thus making the academic experience less onerous. An intelligent system would be beneficial because using technology such as ML would enable the system to adapt to the different traits of the user thus generating an experience unique to them. I envision this solution to function as a mentor to help the user in the skills they struggle with. Taking advantage of different sensory feedback, the system can interact with the user in a seamless and non-disruptive manner. The system decides the mode of interaction with the user depending on their preference as well as the situation they are in. The hope is to design a system that can function within the nuances of university life and aid the user in having a successful academic life. Given the expenses associated with various disabilities, affordable and accessible solutions need to be available to further boost its intended impact.

Limitations and Assumptions

Assumption

I recognize that there are many HFA students in universities who have not received prior educational services or similar support. They could be potential users, but they are not the focus of my study. For this investigation, I assume that the HFA students who interact with this technology have previously received support since their diagnosis. This investigation tries to replicate the prior human support they received to continue that support during university. Considering we live in a digital age, I am assuming a level of digital and technological competence, confidence, and accessibility. This investigation assumes that HFA students are willing to use this technology and are self-motivated to want support for their academic life.

Limitation

This investigation focuses on a specific design intervention for the problem space, and further exploration and research on this solution - or other viable solutions - is encouraged. It is important to note that the study focuses on HFA students enrolled in a professional degree program at a university and are not living at home. While it can still apply to those staying at home, there is more of an immediate need for those living away from their homes and families. Hence, environmental factors will limit this study. Given the nature of the disorder, each person experiences autism differently, and has varying levels of executive functioning, therefore generalizing is not accurate. I am limited by the current research and access to the technology that I am using in this investigation. The machine learning model proposed would require a separate study and design of its own.

Annotated Bibliography

To design for a complex disorder, I read different literature ranging from books, journals, and websites. The materials covered autism beyond just a biological phenomenon. It spoke about the experiences of the individuals with the disorder. The more I read the more I was able to find opportunities where an intervention would be beneficial. Various research materials listed below served as a guide to approach and design this topic with sensitivity and awareness. Another essential topic I researched was the use of technology. I focused particularly on ML and assistive technology. Below is an overview of some literature I covered for this project. I categorized material into 4 categories based on their context.

Machine Learning (ML): A subdiscipline of artificial intelligence that builds algorithms that have the ability to learn without explicitly programmed instructions. (Mohr, Zhang, & Schueller, 2017).

Understanding Disability and Autism

When designing for disabilities, it is important to maintain a user-centric approach. As an individual without that specific disability, we can only empathize and imagine their experiences. Hence it is important to understand methodologies to approach accessibility design and gain a deeper understanding of the disability.

TITLE	CITATIONS
Design meets Disability	Pullin (2011)
Doing Disability Differently	Boys (2014)
Studying Disability	DePoy, Gilson (2011)
Students with mental illnesses in a university setting: Faculty and student attitudes, beliefs, knowledge, and experiences	Becker, Lee, Wajeeh, Ward,& Shern (2002)
Executive Function Deficits in High-Functioning Autistic Individuals: Relationship to Theory of Mind	Ozonoff, Pennington, & Rogers (1991)
Repetitive Behavior Profiles in Asperger Syndrome and High-Functioning Autism	South,Ozonoff, & Mcmahon (2005)
Does the chimpanzee have a theory of mind?	Premack, & Woodruff (1978).
Attention, monotropism and the diagnostic criteria for autism.	Murray, Lesser, & Lawson (2005)

Table 1 Understanding Disability and Autism:
List of literature covered to understand disability and autism.

Autism in Postsecondary Education

Postsecondary education is the first point of independence for many and creates unique hurdles to overcome. Finding challenges within this context for ASD students critical.

TITLE	CITATIONS
Higher Education Experiences of Students with Autism Spectrum Disorder: Challenges, Benefits, and Support Needs	Hees, Moyson, & Roeyers (2014).
Educational Experiences and Needs of Higher Education Students with Autism Spectrum Disorder	Cai, & Richdale (2015)
Promoting Academic Engagement for College Students with Autism Spectrum Disorder	McKeon, Alpern, & Zager (2013)
Transition to Adulthood for High-Functioning Individuals with Autism Spectrum Disorders	Kapp, Gantman & Laugeson (2011)
Evaluating the College Transition Needs of Individuals With High-Functioning Autism Spectrum Disorders	Adreon, & Durocher (2007)
Supporting Students With Asperger Syndrome on College Campuses: Current Practices	Barnhill (2014)
Systematic Review of Articles Describing Experience and Supports of Individuals with Autism Enrolled in College and University Programs	Gelbar, Smith, & Reichow (2014)
Autism and the University Experience: Narratives from Students with Neurodevelopmental Disorders	Bolourian, Zeedyk, & Blacher (2018)

Table 2 Autism in Postsecondary Education:
List of literature covered to understand autism in postsecondary education.

Autism and Machine Learning Technology

Since autism is a spectrum disorder, with everyone having their own unique traits, ML has the potential in adapting and responding uniquely to the individual and their situation. Discerning how the advantages of ML can be used for this purpose is beneficial.

TITLE	CITATIONS
Crowdsourced validation of a machine-learning classification system for autism and ADHD	Duda, Haber, Daniels, & Wall (2017)
Personal Sensing: Understanding Mental Health Using Ubiquitous Sensors and Machine Learning	Mohr, Zhang, & Schueller (2017)
Private traits and attributes are predictable from digital records of human behavior	Kosinski, Stillwell, & Graepel (2013)
Computer-based personality judgments are more accurate than those made by humans	Youyou, Kosinski, & Stillwell (2015)
Distance-Based Computational Models for Facilitating Robot Interaction with Children	Feil-Seifer, & Mataric (2012)

Table 3 Autism and Machine Learning Technology:
List of literature covered to understand machine learning related to autism.

Assistive Technology

Based on the project's goal, this topic is critical to the project's development. I need to understand how the current technology works and its capabilities. With that I will be able to make an informed choice and implement the technology for this project.

TITLE	CITATIONS
In the Shadow of Misperception: Assistive Technology Use and Social Interactions	Shinohara, & Wobbrock (2011)
Designing a Wearable Technology Intervention to Support Young Adults With Intellectual and Developmental Disabilities in Inclusive Postsecondary Academic Environments	Evmenova, Graff, Motti, Giwa-Lawal, & Zheng (2018)
Social Communication Coaching Smartglasses: Well Tolerated in a Diverse Sample of Children and Adults With Autism	Keshav, Salisbury, Vahabzadeh, & Sahin (2017)
Assistive Technology for Postsecondary Students with Disabilities	Lang, Ramdoss, Sigafoos, Green, Meer, Tostanoski, … O'Reilly (2014)
Assistive Technology for People with Autism Spectrum Disorders	Lang, Ramdoss, Raulston,, Carnet, Sigafoos, Didden, … O'Reilly (2014)
Reducing the Need for Personal Supports Among Workers with Autism Using an iPod Touch as an Assistive Technology: Delayed Randomized Control Trial	Gentry, Kriner, Sima, Mcdonough, & Wehman (2014)
Personal digital assistants as cognitive aids for high school students with autism: Results of a community-based trial	Gentry, Wallace, Kvarfordt, & Lynchz≈ (2008)
Personalized Coaching Systems to support healthy behavior in people with chronic conditions	Hermens, Akker, Tabak, Wijsman, & Vollenbroek (2014)
Considering student choice when selecting instructional strategies: a comparison of three prompting systems	Taber-Doughty (2005)

Table 4 Assistive Technology:
List of literature covered to understand Assistive Technology.

Framework

I examined different theoretical frameworks to understand the functioning of the system. This allowed for a stronger knowledge base which helped me develop a blueprint to support the proposed designed system.

Higher Education Experiences of HFA students

Hees and Moyson discuss a framework for the education experience of HFA students in higher education. The framework (as seen in fig 4) is a compilation of the data collected and organized to make the information more cohesive.

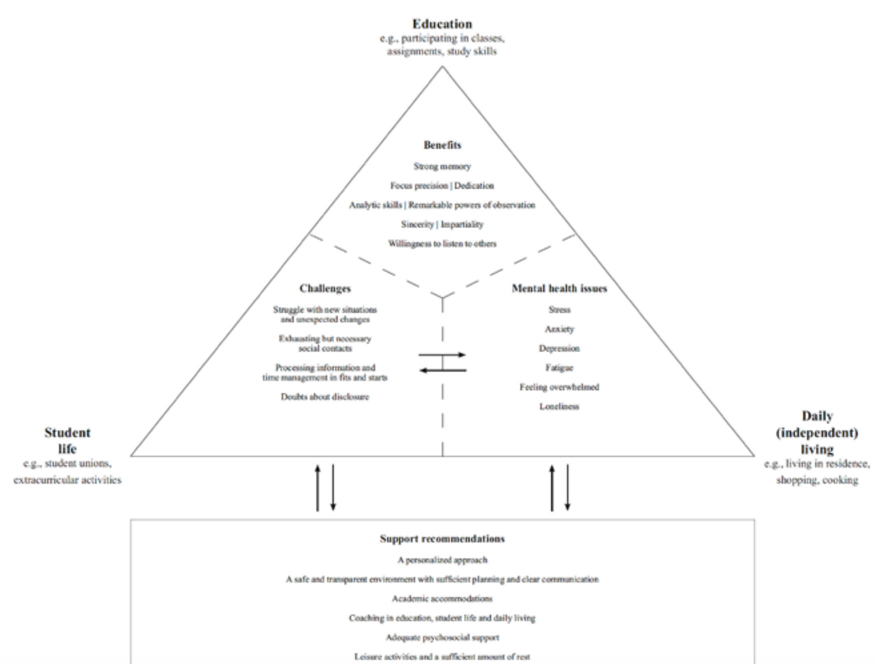

Figure 4 Higher Education Experiences of students with ASD:
This framework by Hees and Moyson depicts the components of college life for students with autism.

Hierarchical Sensemaking Framework

To add information, raw sensor data must be transformed into features. Features are constructs measured by, and proximal to, the sensor data (Mohr, Zhang & Schueller, 2017).

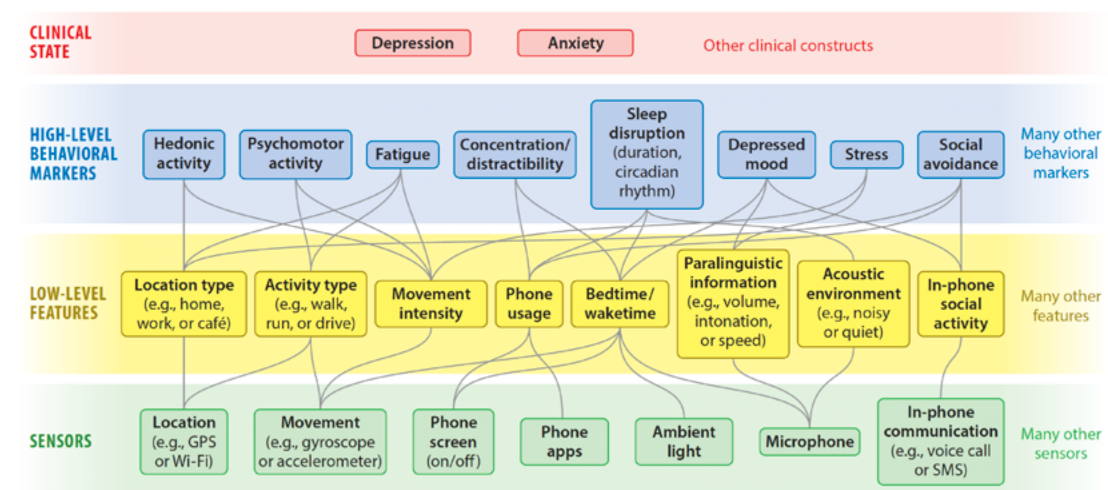

Figure 5 Layered Hierarchical sensemaking framework:
This shows the hierarchical connection between sensors and behavioral markers.

Theory of Planned Behavior

The theory of planned behavior links one's beliefs and behavior. The theory states that attitude toward behavior, subjective norms, and perceived behavioral control, together shape an individual's behavioral intentions and behaviors (Ajzen, I. 1991).

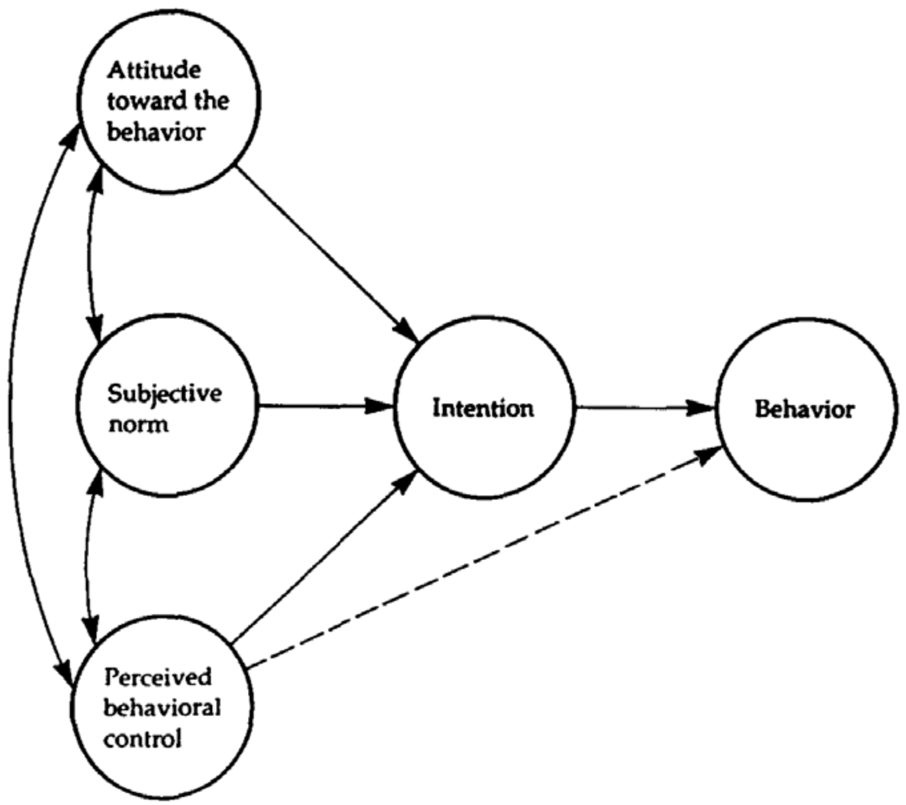

Figure 6 Theory of Planned Behavior Framework:
The framework shows how intention can affect behavior.

Theory of Mind

People do not think or feel the same way. How the other person feels about a topic is a part of communication and this understanding is theory of mind. Theory of mind is the ability to attribute mental states — beliefs, intents, desires, emotions, knowledge, etc. — to oneself, and to others, and to understand that others have beliefs, desires, intentions, and perspectives that are different from one's own (Premack, D., & Woodruff, G., 1978). The ability is critical for communication and resolving issues. In fig 7 you can see the different tools of theory of mind (Malle, 2020). The complexity increases as you move to the top of the triangle.

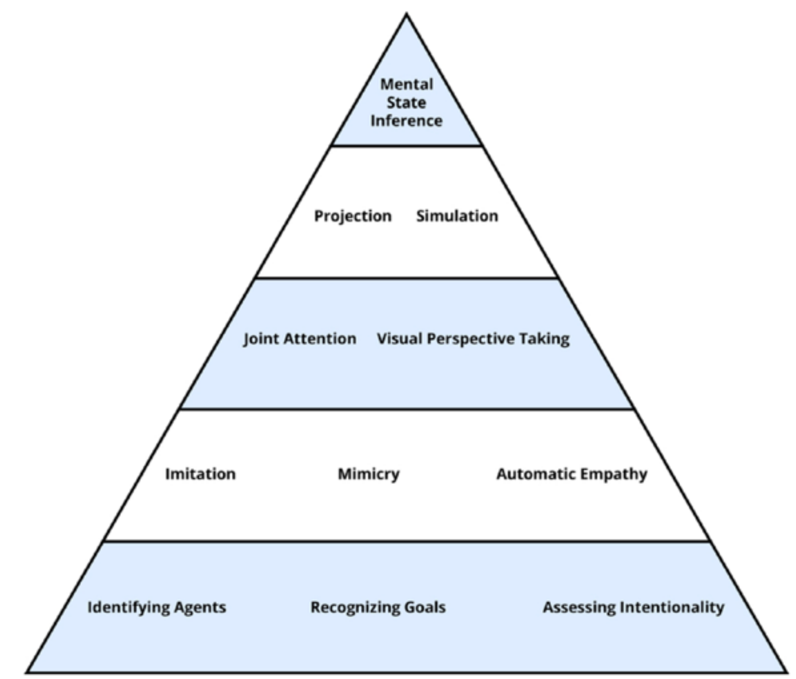

Figure 7 Theory of Mind Tool Set:
The framework shows the different tools of theory of mind. As you move the bottom to the top, the complexity of the tool increases.

Deep Reinforcement Machine Learning

Reinforcement learning (RL) is a Machine Learning paradigm, it is about taking suitable action to maximize reward in a particular situation. Fig 8(Galatzer-Levy, Ruggles, &Chen, 2018) shows the diagram of the system. The RL is presented with a complex goal, for instance, the goal is to find all the cats in a photograph. The algorithm adopts a heuristic approach to reach its goal. Every time the system finds all the cats, it gets rewarded.

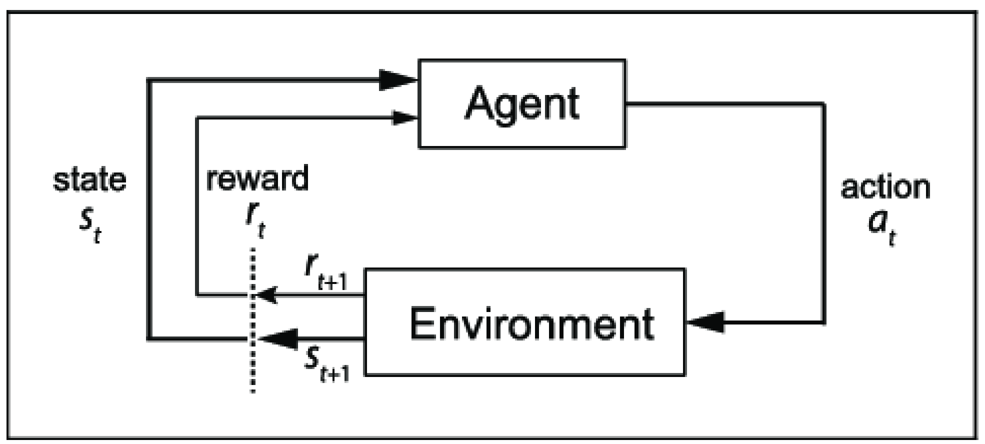

Figure 8 Reinforcement learning:
The diagram shows the agent and the environment interact with each other to maximize reward.

With Deep reinforcement learning (DRL), a deep neural network is added to the reinforcement model. This allows the model to map between a state and the best possible action without needing to store all possible combinations (Chen, Zhang, Wu, Mao, Ji, & Bennis , 2019).

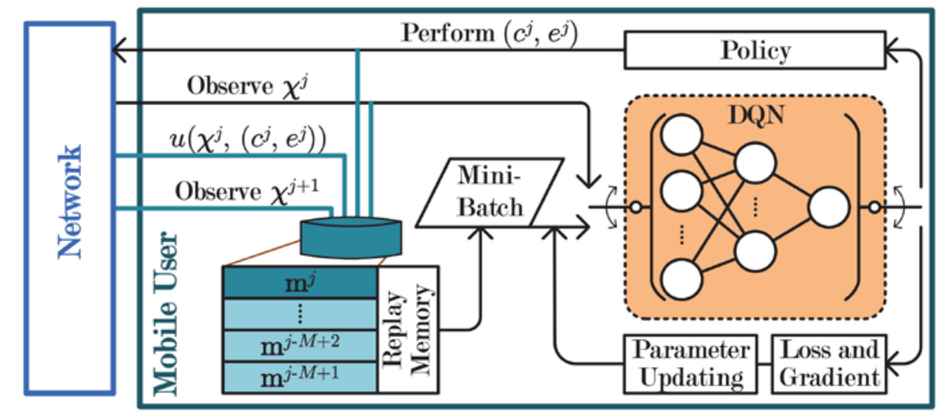

Figure 9 Deep Reinforcement Learning:
This framework combines Reinforcement learning (fig 8) with deep neural networks to allow for the best possible action

Conceptual Framework

With the help of DRL, the ML model learns how to respond and interact with people on the spectrum creating a training dataset. The dataset exists on an online cloud. Initially, the mediating device uses this repository to respond to the user. Every time the ML model responds correctly, it gets a positive reward. The more the individual uses the system, the more accurately it will learn to respond. The model learns from the sensor data and the human's response. This allows the modification of the dataset, making it unique for that specific user.

Executive functions are a set of cognitive skills that help us perform different tasks like time management (McKeon, Alpern, & Zager, et al 2013). For those on the spectrum, certain executive functions are not as strong, making tasks difficult. Sensors connected to the user (smartwatches or phones, for instance) can track the users' abilities and behavior. The sensor data is used to update the dataset to increase the ML model's accuracy. The more the sensor data sent by the user, the more articulate the results will be.

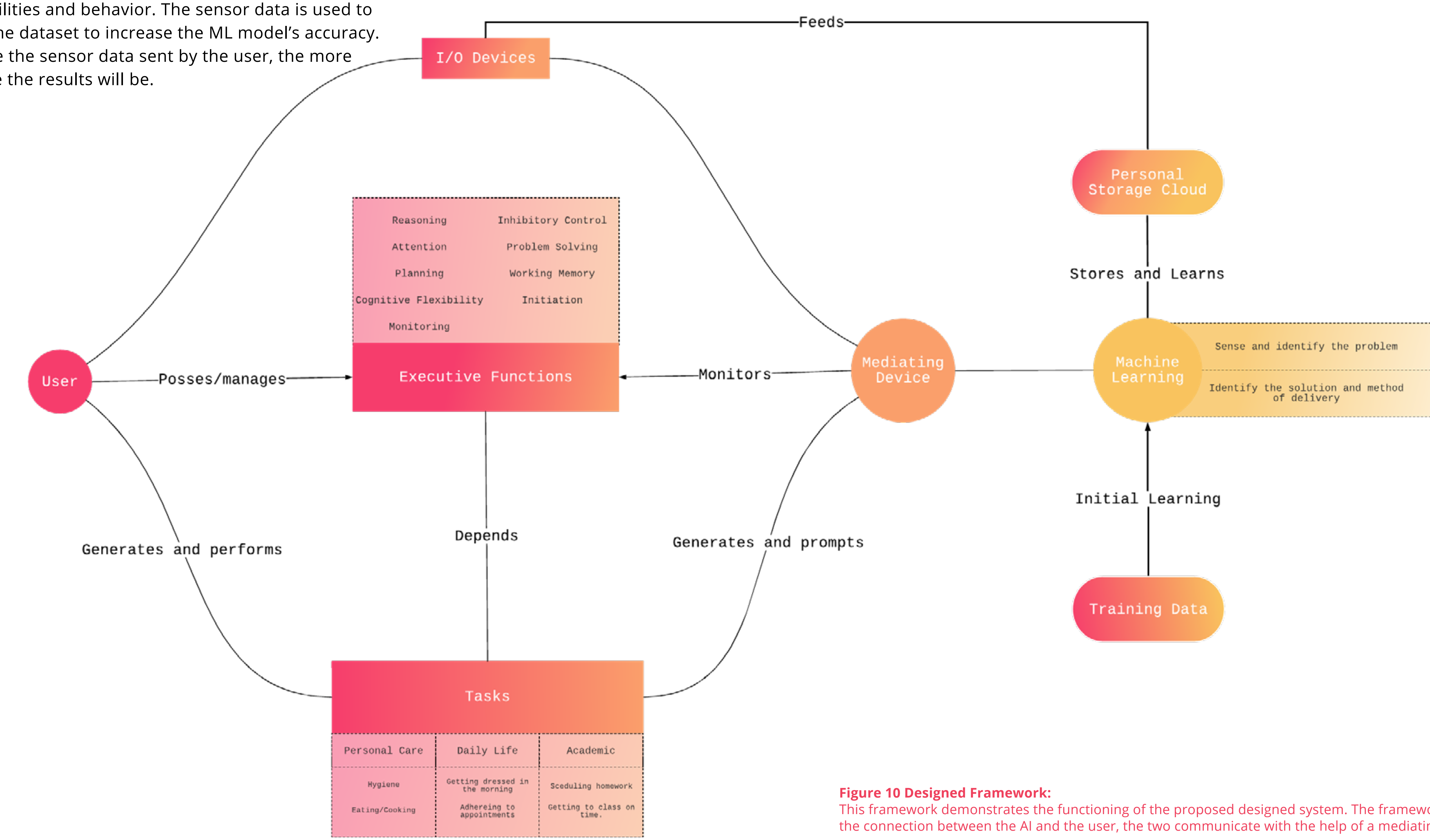

Figure 10 Designed Framework:
This framework demonstrates the functioning of the proposed designed system. The framework shows the connection between the AI and the user, the two communicate with the help of a mediating device.

Research Questions

Primary Question

How might we design sensory interactions for an intelligent peer mentoring system to assist university students with high functioning autism to independently manage their academic life?

Sub Questions

1. How can a communication link be established between the user and the system to monitor and support the user?

2. How can sensory interactions be used to help the user be in equanimity in stress-induced moments which render them non-functional?

3. How can the ML component of the system use sensory interactions to assist in problem-solving?

4. How can sensory interactions be used to aid and guide the user in completing tasks?

Definition of Terms

TERM	DEFINITION
Sensory Interactions	The integration of sensory processes when performing a task, as in maintaining balance using sensory input from both vision and proprioception.
Autism Spectrum Disorder	A neurodevelopmental disorder that affects an individual's social and communication skills and is characterized by repetitive/restrictive behavior
Machine Learning	An application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed.
Academic Life	Activities and tasks that support or relate to colleges or universities
Assistive Technology	Any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of a child with a disability.
Neurotypicals	Individuals without developmental disorders.
Executive Functions	Set of cognitive processes that are necessary for the cognitive control of behavior: selecting and successfully monitoring behaviors that facilitate the attainment of chosen goals.

Table 5 Definition of Terms:
Definition of recurring and important terms used in this document.

METHODOLOGY

Overview

The methods listed below are the research methods I used to work on this project.

Concept Mapping

Concept mapping is a visual framework that allows designers to absorb new concepts into an existing understanding of a domain so that new meaning can be made (Hanington & Martin, 2012).

Precedent Studies

I critically analyzed a diverse range of solutions focused on autism. I conducted a total of 3 precedent studies to gain a deeper knowledge. I evaluated them using a metric sheet to identify key features of the products

Interviews

Interviews are a fundamental research method to collect firsthand personal accounts of experience, opinions, attitudes, and perceptions (Hanington, B. M., & Martin, B., 2012).

I conducted semi structured interviews with experts who directly engage with individuals on the spectrum. The interview allowed me to get a deeper understanding of the users and define this project.

Persona and Scenario

Personas consolidate archetypal descriptions of user behavior patterns into representative profiles, to humanize design focus, test scenarios, and aid design communication (Hanington, B. M., & Martin, B., 2012).

I created hypothetical users, based on spectrum typologies. The user persona is placed in a plausible hypothetical situation to identify moments of intervention and opportunities.

User Journey Map

A user journey map is a visualization of the experiences people have when interacting with a product or service. The experience includes feelings, perceptions, etc. In the user journey map each moment can evaluated individually and improved (Hanington, B. M., & Martin, B., 2012).

Research through Design

Research through design examines the tools and processes of design thinking and making within the design project, bridging theory, and building knowledge to enhance design practices (Hanington, B. M., & Martin, B., 2012).

Prototyping

Prototyping is the tangible creation of artifacts at various levels of resolution, for development and testing of ideas within design teams and with clients and users (Hanington, B. M., & Martin, B., 2012).

Precedent study

Products Designed for Disability and Autism

QUALITIES / PRODUCT	TANGLIBLE [MOBILE DEVICES NOT CONSIDERED]	TECHNOLOGY	SMART OBJECT	AIMED AT KIDS	AIMED TO CALM	AIMED AT COMMUNICATION	SOCIAL INTERACTION [NOT LIMITED TO FAMILY & THERAPIST]	OTHER CHARACTERISTICS
SYNCHRONY	yes	bluetooth, sensors		yes	yes	yes		music, communication, parent-therapist-child. Love this.
:PROSE	had a tangible element associated with it but the domain isn't functional.	iOS	has potential with the smartstone touch which doesn't seem to be availible	yes		yes	yes	iOS exclusive, communication for non-verbal. Read more.
PROLOQUO4TEXT		mobile app				yes	yes	for non- verbal, predictive text, iOS
LEKA	yes	robot	yes	yes		yes		educational toy
GOOGLE GLASS	yes	facial recongition	yes			yes	yes	google glass is discontinued but used for projects
WEARABLE SOCIAL COACH	yes	wearable tech, AI	yes			yes	yes	The system runs on a Samsung Simband, MIT project
WATCHMINDER	yes	wearable tech, programmable	no					Stay organized.
REVEAL	yes	wearable						didn't get enough funding; focused on anxiety
Empowered Brain	yes	AI, google glass, AR	yes			yes	yes	behavious self-control for transitions, job skills

Table 6 Products Designed for Disability and Autism:
Analysis of products designed for disability and autism.

Figure 11 Synchrony:
Synchrony is a therapeutic instrument designed to help parents and children with autism develop intimacy and promote understanding of each other through improvised music play.

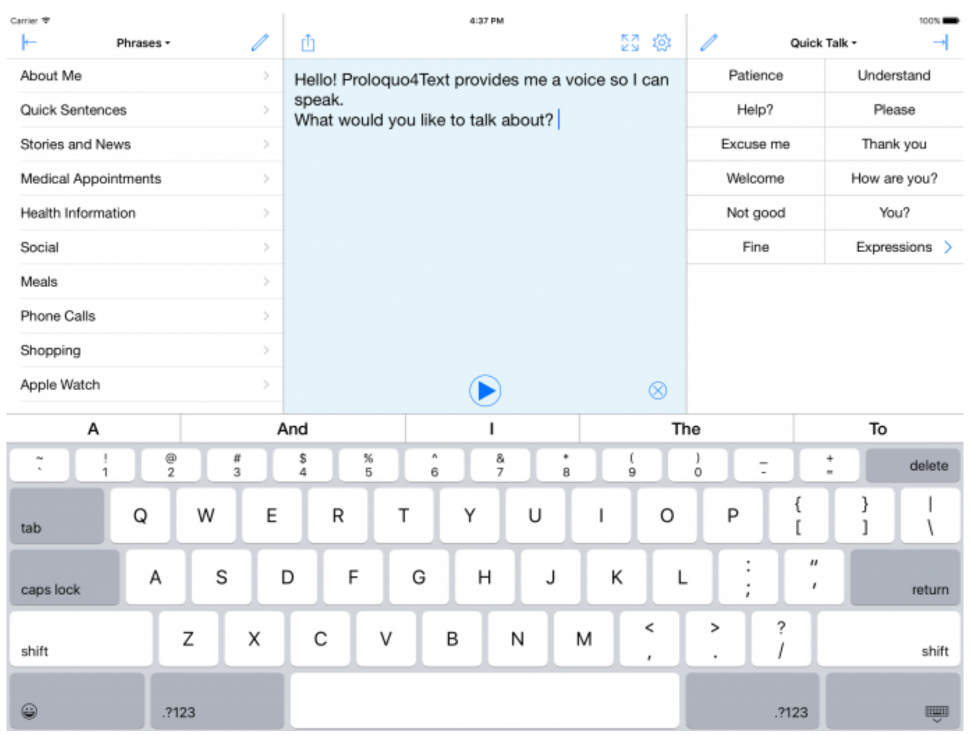

Figure 12 Proloquo4Text:
Proloquo4Text is a text-based app for nonverbal people, to help them communicate their typed words into speech.

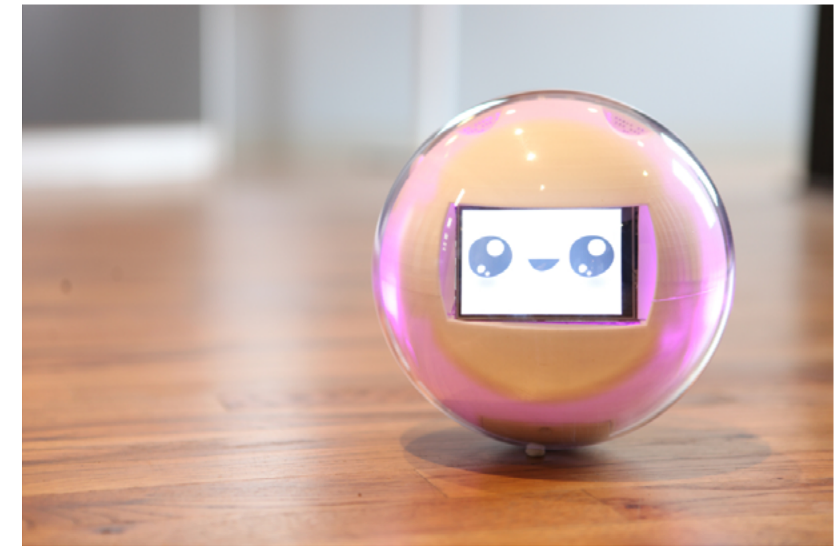

Figure 13 Leka:
Leka is an interactive robotic companion used to help children with autism learn to communicate.

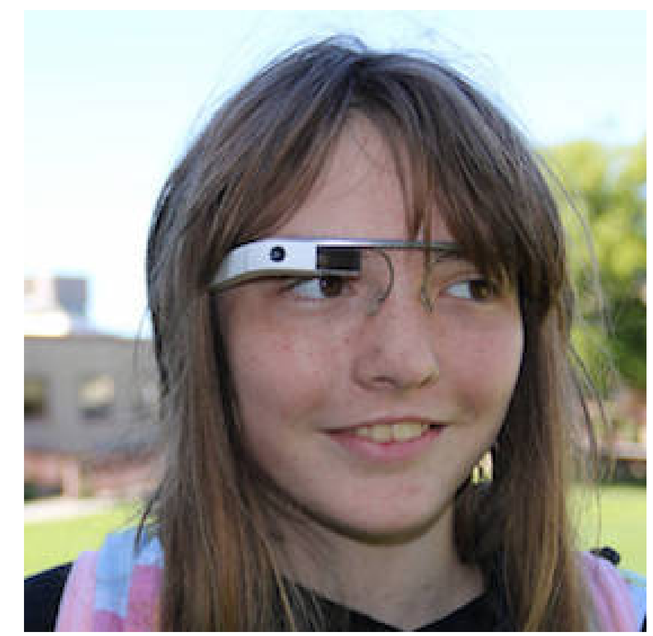

Figure 14 Google Glass:
The project by Stanford uses artificial intelligence to recognize facial is an interactive robotic companion used to help children with autism learn to communicate

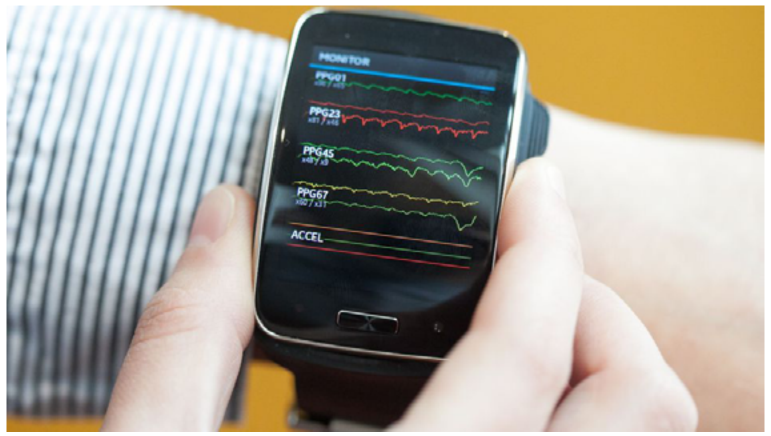

Figure 15 Social Coach:
A wearable integrated with AI to decipher the overall tone of the communication.

Figure 16 Watch Minder:
An assistive programmable watch to help students with ADHD stay focused.

Figure 17 Empowered brain:
A computerized pair of glasses designed to help children learn social-emotional skills.

Products for Productivity and Management

QUALITIES / PRODUCT	TECHNOLOGY	TANGLIBLE	BEHAVIOUR TRACKING	MANAGEMENT	MODE OF COMMUNICATION	OTHER CHARACTERISTICS
SAENT	Smart Device + desktop app	yes	yes	yes	touch gestures, visual	Distraction blocker, Do not disturb button, Smart breaks, Store data locally for privacy
LUXAFOR FLAG	USB connection software-controlled LED	yes	no	yes	visual	has add-on devices and a API that can be used to tailor functionalities
AUTISMTRACK	Mobile App (iOS)	no	yes	no	Visual	Visual Custom Tracking
FITBIT VERSA	Smart Device + Mobile app	yes	yes	yes	visual,haptic, with alexa - auditory	Customizable, Personalized Reminders, Smart Tracking
AUTIPLAN	App	no	no	yes	visual	has templates, icons for faster scheduling and can take print outs
WEARABLE SOCIAL COACH	wearable tech and AI deep-learning add-on	yes	no	no	visual	MIT project,analyze audio, text transcriptions and physiological signals to help determine a conversation's overall tone in real-time.
WATCHMINDER	Wearable Tech watch	yes	no	yes	visual and has buttons	
FIDGI PEN	Fidgeting device + pen	yes	no	yes	tactile	Discreet, helps keep calm
EMPOWERED BRAIN	google glass, AR	yes	no	no	visual, gestures	Gamified and Motivational
CHOICEWORKS	App	no	no	yes	visual, touch, speaker	Share boards by Email, Files app or iTunes
IPROMPTS	App	no	no	yes	visual, touch	Visual Countdown Timer,Choice Prompts

Table 7 Products for Productivity and Management:
Analysis of products designed for productivity and management.

Figure 18 Saent:
A smart device and desktop app that is used to boost productivity.

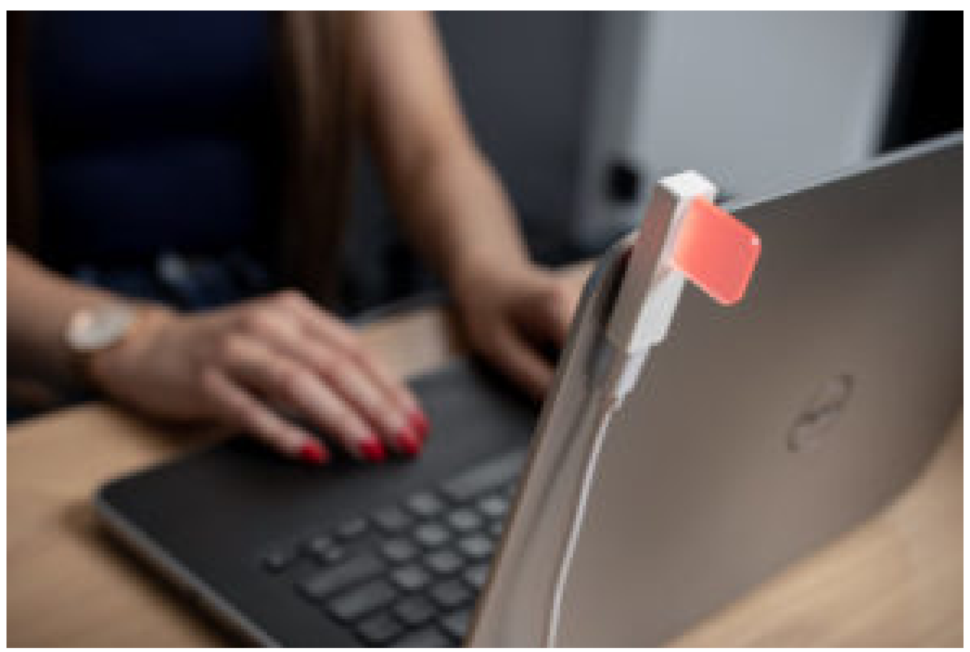

Figure 19 Luxafor Flag:
It deduces the workplace distractions and organizes workflow for better results

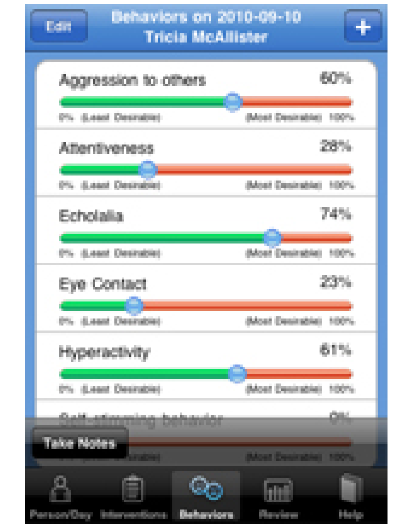

Figure 20 AutismTrack:
A customizable data tracking tool that empowers caregivers of those with autism to easily track interventions, behaviors, and symptoms.

Figure 21 Fitbit Versa 2:
A health and fitness smartwatch. It keeps track of sleep, level of activeness, and can receive notifications.

Figure 23 Fidgi Pen:
The Fidgi Pen has 7 unique features embedded in it to help you stay calm, focused and in the moment.

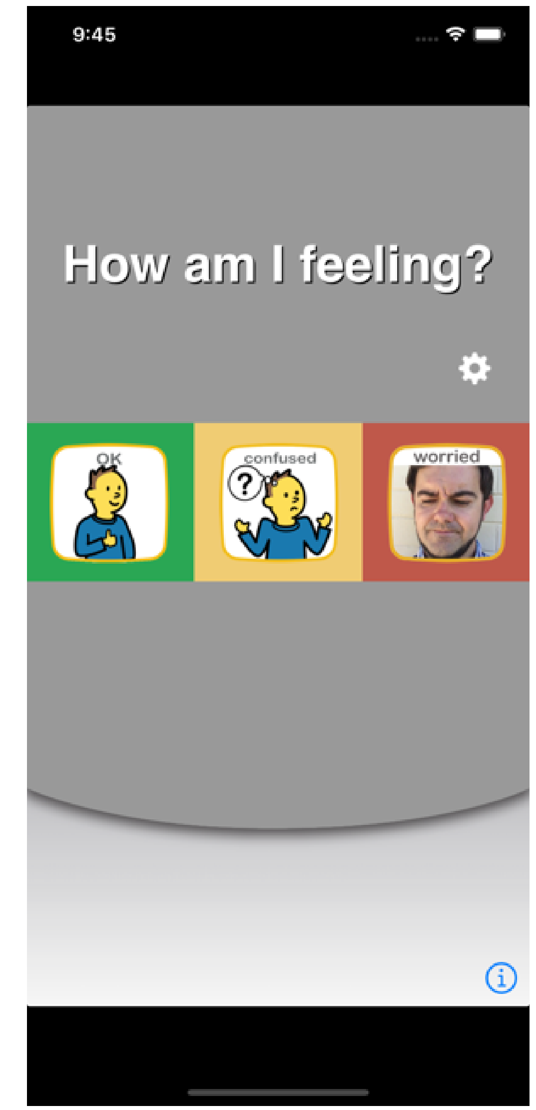

Figure 24 Choiceworks app:
The Choiceworks app is an essential learning tool for helping children complete daily routines, understand & control their feelings, and improve their waiting skills.

Latest Wearable Technology

QUALITIES / PRODUCT	Location on Body	BioFeedback	Main Functionality	App	Interaction points	Other Characteristics
MUSE	Head	EEG, heart, body, breathing	Focus	iOS/Android	via the App	
Eargo	Ears	N/A	amplify/ cut out noise	N/A	Audio	4 sound profiles
Motiv Ring	Finger	Heart, Sleep, Steps	Fitness	iOS/Android	via the App	Adjust daily targets for fitness
Feel	Wrist	physiological signals	Emotion and Mental Health tracking	iOS/Android	via the App	Combines CBT
SoundWear Companion speaker	Shoulder/Neck	N/A	Hands free speakers with focused wave tech	iOS/Android	via the App; Voice	
DropLabs Ep 01 Sound Immersion Footwear	Feet	N/A	Enhance haptic sensory of the environment and music	iOS/Android	via the App	
Tap Strap 2	Fingers	N/A	Keyboard replacement. Mouse and Air gestures controller.	N/A	button	Can be used on AR/VR platforms apart from bluetooth devices
Embr Wave Bracelet	Wrist	N/A	personal thermostat	iOS/Android	App; button	
Wove Band [won't be released so combining the screen text with Fitbit capabilities]	Wrist	Heart, Sleep, Steps	flexible GPS smartwatch packed with fitness guidance, 24/7 heart rate, health and wellness insights, on-screen workouts, phone-free music, payments and more.	iOS/Android	via the App; Touch	replaces apps with compositions
HiiDii Glasses	Face	N/A	Mouse functionalites by just blinking and headmovement. Hands free.	iOS/Android	via the App; eyes and head movement	multiplatforms
AlterEgo [Not for commerical purpose yet]	head	N/A	Engage with a personal assistant by internally talking.	N/A	Bone conduction	Accessibility

Table 8 Latest Wearable Technology:
Analysis of the latest products in wearable technology.

Figure 25 Muse S:
Muse S is a comfy multi-sensor meditation device that provides real-time feedback.

Figure 26 Eargo:
Eargos amplify speech while reducing background noise, making it easier and more comfortable to hear in noisy settings.

Figure 27 Motiv Ring:
Motiv Ring is the first smart ring designed for 24/7 wear. Track your fitness, heart rate, and sleep, and protect your online identity.

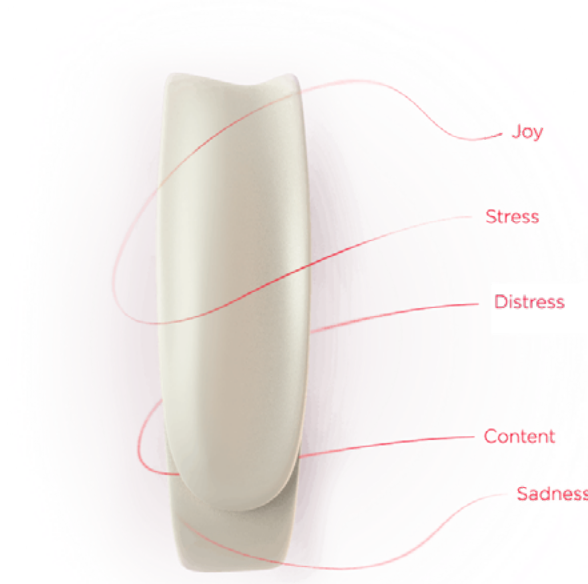

Figure 28 Feel:
The Feel program combines its proprietary Feel Emotion Sensor and Cognitive Behavioral Therapy (CBT) to quantify a person's emotional state for the very first time, and deliver 24/7/365 emotional health support to those in need.

Figure 29 SoundWear Companion speaker:
A wearable speaker that rests comfortably on your shoulders, with sound that is full and clear to you—yet minimizes the sound for others.

Figure 30 DropLabs Ep 01 Sound Immersion Footwear:
Patented hardware and software convert audio input into vibrations via Bluetooth, stimulating nerve receptors in your feet for a range of intensity and feeling that resonates throughout your entire body.

Figure 31 Tap Strap 2:
It's an all in one, wearable keyboard, mouse & air gesture controller.

Figure 32 Embr Wave Bracelet:
The Wave Bracelet activates your thermal senses, connected to your perception of temperature, with cooling and warming sensations.

Figure 33 HiiDii Smart Glasses:
HiiDii Smart Glasses interact with your device just by blinking your eyes and turning your head to move the cursor.

Figure 34 AlterEgo:
AlterEgo is a non-invasive, wearable, peripheral neural interface that allows humans to converse in natural language with machines, artificial intelligence assistants, services, and other people without any voice—without opening their mouth, and without externally observable movements—simply by articulating words internally.

Interview Summary

I divided the interview content into two parts. The first part informed my initial research to learn more about the problem space. The second part is where I delved deeper into the topic to understand the nuances and better represent the situation.

Part 1:

There is a wide range of disabilities that are present on a university campus. This often makes the task of helping students difficult for the disability resource office to cater to diverse needs. Campuses heavily rely on the student disclosing their disability to get the support they need. Oftentimes the accommodations required are circumstantial thus making it more important for the individual to tell the assistance they need. For accommodations to work, the rules of the workspace need to work in coordination with the individual's rules. Making campus resources accessible is not an easy feat. There are a vast number of websites and other applications that are operated by different sections on campus. It is important to understand, the goal is to help people articulate their goals and guide them in problem solving. The individual directs their own life, no one is dictating what needs to be done.

Many do not really know what autism is and it is hard to pinpoint characteristics. Ritualistic behavior is common among those with autism. Some prefer doing their activities at certain locations while others tend to perform an activity only at a specific time. There is a lot of variation. There is a lot of patience required from both the person with autism and the neurotypical. Spontaneous gestures can be overwhelming, it is always recommended to ask the individual before you do anything. The more things are planned the easier things will be. It is also important to have written alternatives since some people are non-verbal.

Looking at colleges specifically, many students on the spectrum tend to take up single rooms since they feel conscious about their rituals and do not want to be a disturbance. Since they stay alone, there is no one to wake them up. They lose track of time by getting engaged in playing games and forget to attend class. In some cases, students are not aware of the resources that are available for them. There is a communication barrier that exists for people on the spectrum, be it their parents or their peers. You need to respect the individual's space to help build a relationship for them to communicate with you. They might communicate differently but knowing they are being heard, is a step in the right direction.

Part 2:

Autism is more of a grid (as seen in fig 2 & 3); some individuals are HF in cognitive abilities but lower in communication. A prospective ASD persona may have vastly different profiles based on number of issues/categories. There is a stark contrast between cognitive abilities and executive functions among individuals with autism. While some struggle with just eating breakfast, another might eat lunch only at a specific time. Oftentimes, students struggle with compartmentalizing their time. Balancing their time is a common struggle.

There are lots of situations where a meltdown is caused by something like a change in location. Meltdowns manifests in different forms, there are students who get angry when they have a meltdown which can cause them a lot of issues. Sometimes the best solution might be to remove themselves from the situation or avoid talking to certain people before major events. To stem the effects of the meltdown, people take up different forms of intervention. Fidget toys being quite popular among them, it helps them get out their nervous energy. Some prefer to walk out of the room and come back once calm. Many take up playing on their phones, even though they are on their phone they are aware of the conversation taking place and their emotions. It is interesting to note that students who use their phones as an intervention will always reach out for their phone when they need to calm down.

When working with individuals on the spectrum it is important to understand that many say things without a filter which sometimes might not be socially acceptable. The conversation needs to be direct and one needs to avoid sarcastic comments at all costs. Understanding the individual's receptive and expressive language is essential as it will determine the nature of the intervention or communication. Written alternatives for interventions should be accessible. Some individuals might require proactive check ins since their parents or home-based support undertook the role of prompters and reminders.

User Journey

Based on literature research and interviews, I developed 3 different user personas to capture the diversity of people with autism. However, it still does not represent the holistic view of people with this disability. I mapped out their experiences based on their different abilities and preferences. Using these experiences, I was able to find pain points and begin my explorations for the design of the system.

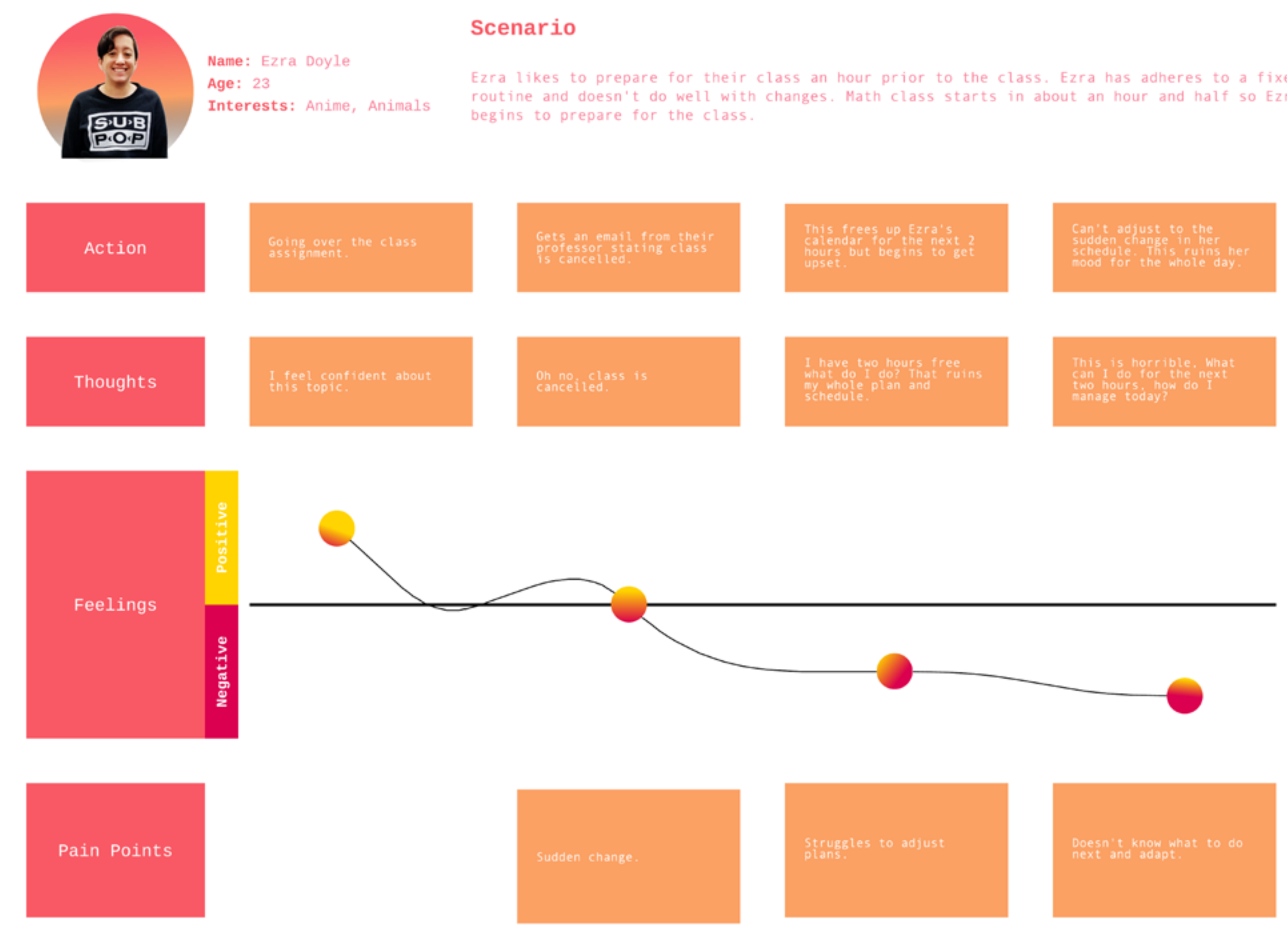

Figure 35 User Journey Map - Ezra:
The user journey map walks through Ezra's experience. The map identifies the user's emotions and pain points during the scenario. From the map, I was able to identify moments Ezra struggles with.

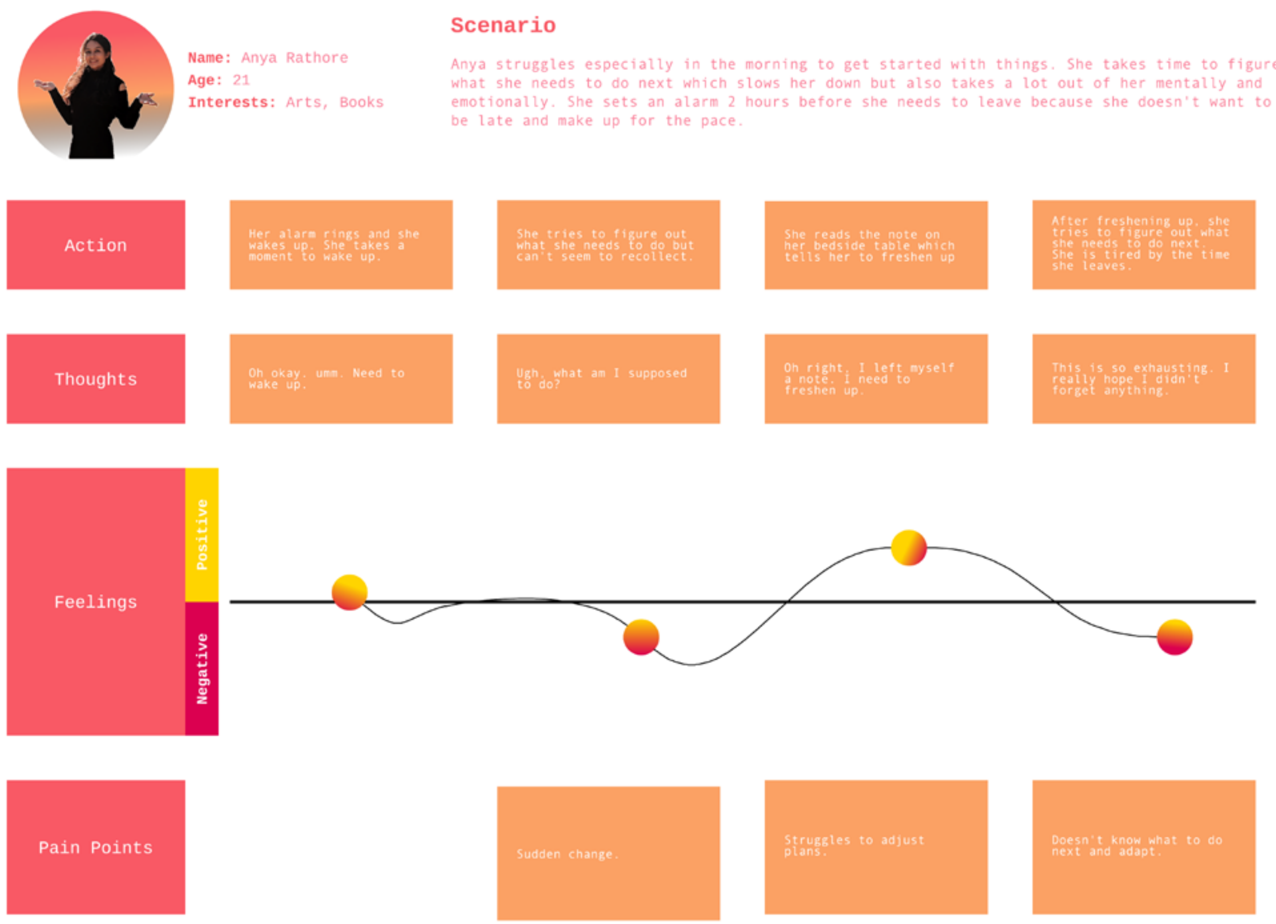

Figure 36 User Journey Map - Anya:
The user journey map walks through Anya's experience. The map identifies the user's emotions and pain points during the scenario. From the map I was able to identify moments where I can intervene to support Anya's situation.

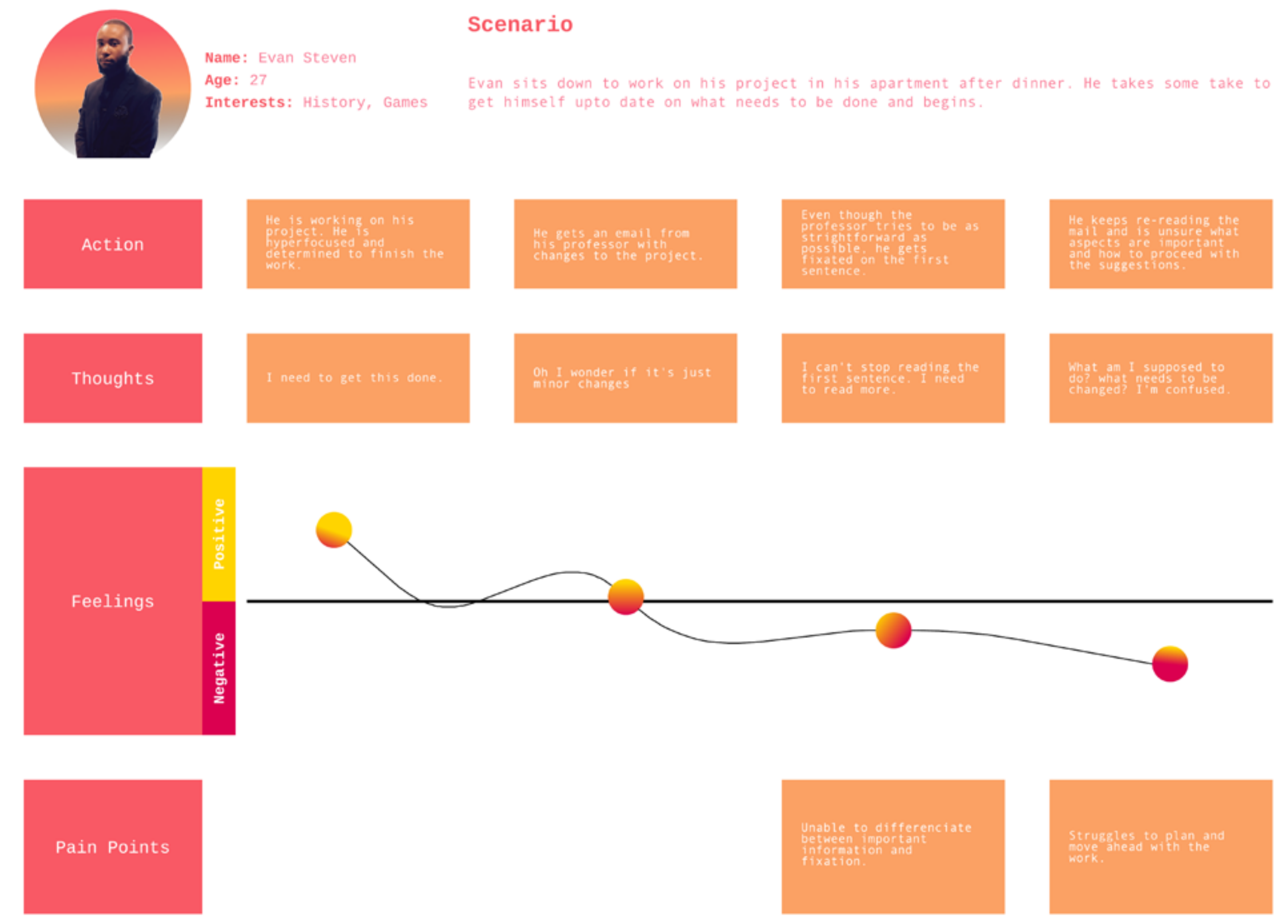

Figure 37 User Journey Map - Evan:
The user journey map walks through Evan's experience. The map identifies the user's emotions and pain points during the scenario. From the map, I deducted Evan's communication pain points.

Conversational User Interface

AI Design:

For the project to move forward, there needed to be a medium or interface through which the computer could converse with the user. Thus, the need for Conversational User Interface (CUI). I delved into learning and developing the CUI system, the quality of the relationship was critical to its success. How the person perceives the AI would affect the quality of the mentor relationship. I investigated the personality traits that are sought after in a mentor and worked on designing an AI system embodying those characteristics. The explorations ranged from form to language.

Purpose

The system's purpose is to help users perform certain tasks and functions.

Privacy nature

The user controls the degree of involvement of the AI and when the system intervenes. The system does not decide things for the user, it creates a collaborative environment where the human's capabilities are augmented.

AI persona quality

- Gender fluid (he/she/it)
- Talks as much as the user needs it to
- Great listener
- Patient
- Calm
- Approachable
- Attentive
- Versatile
- Adaptive

Form

Avatar forms ranged from human avatars, anthropomorphic characters, and abstract forms. After a series of iterations, abstract forms cast a closer representation of the AI personality.

Figure 38 Visual Forms:
Initial forms explored to represent the AI personality.

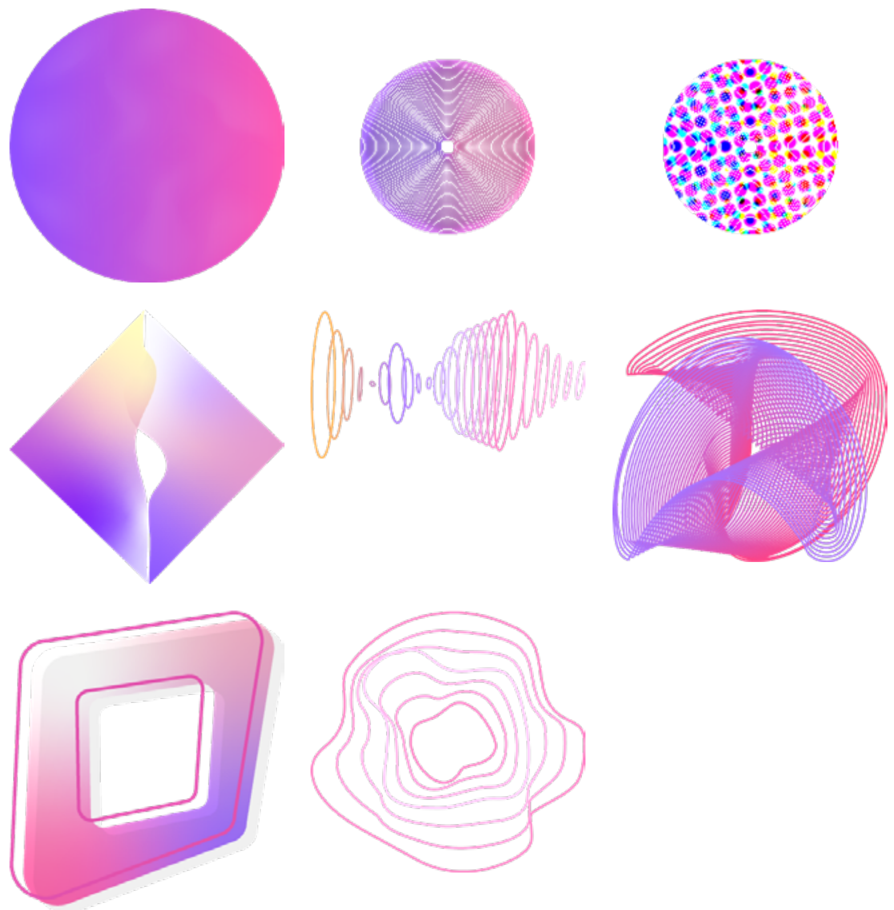

Figure 39 Abstract Visual Forms:
Different abstract visuals explored to represent the AI personality.

Conversation Design:

Discerning the depth and complexity of a conversation required mapping conversations between the user and the AI system. The user's personality and the mode of conversation were critical to the nature of the conversation. Utilizing a range of software such as Voiceflow, uncovered different trajectories and possibilities for the flow of the conversation. This exploration allowed for refining sentences, word choices, and approaches.

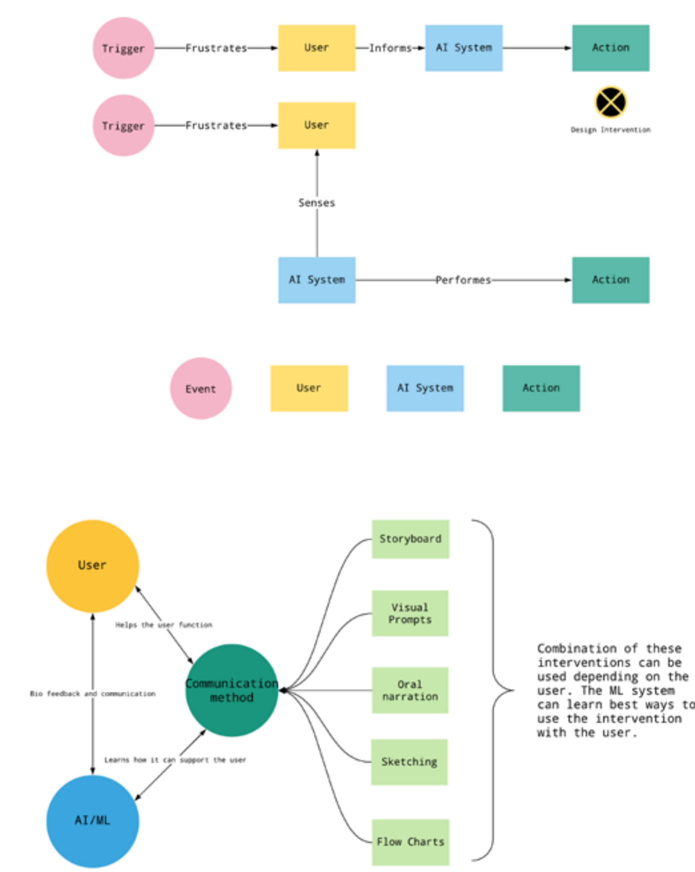

Figure 40 Conversation Mapping:
Generating a base structure to develop different conversations.

Figure 41 Game Intervention Conversation:
The flowchart maps out the conversation between an AI and the user when gaming is used as an intervention.

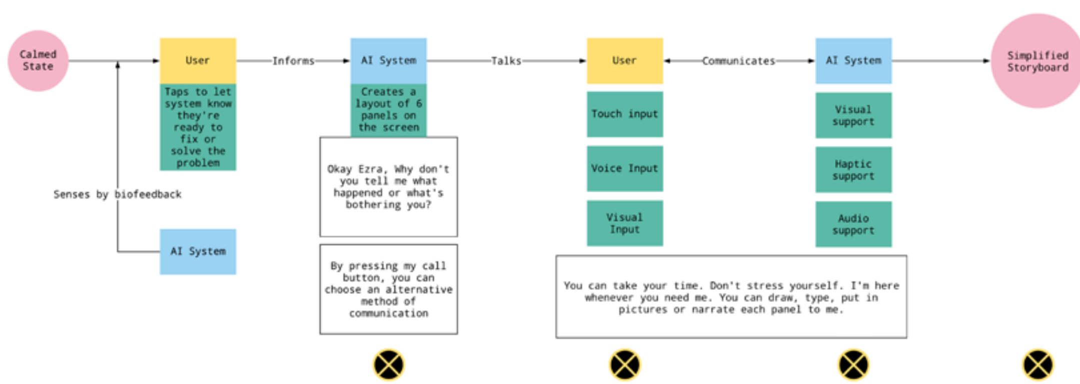

Figure 42 Getting in touch:
The flowchart maps out the communication conversation between the AI and the user.

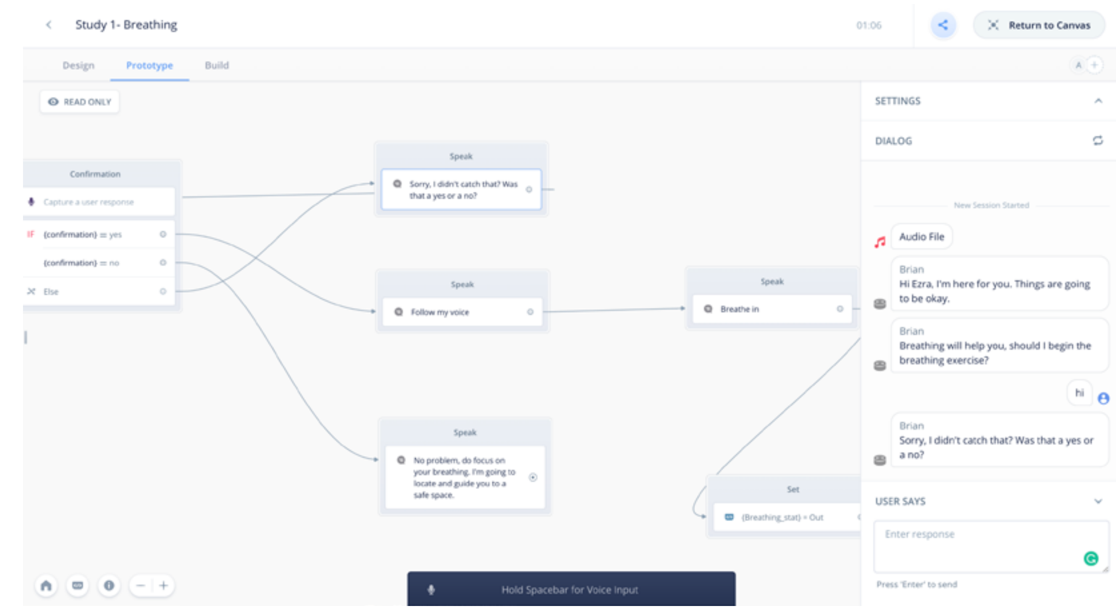

Figure 43 Voiceflow Conversation -1:
This is a screenshot of the testing of a conversation designed on Voiceflow.

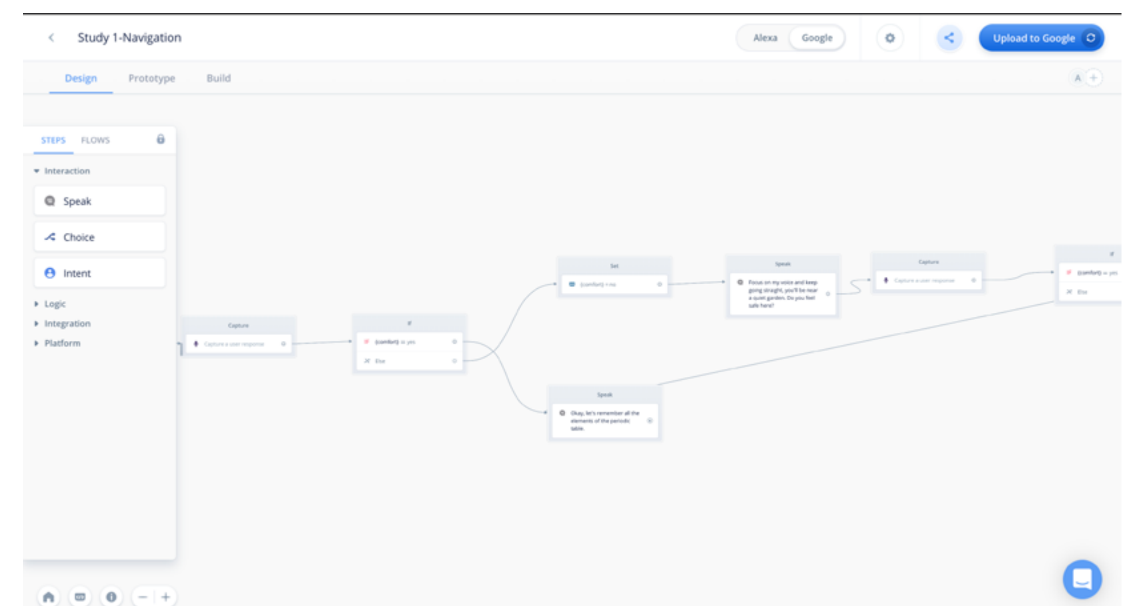

Figure 44 Voiceflow Conversation -2:
This is a screenshot of the conversation designed on Voiceflow.

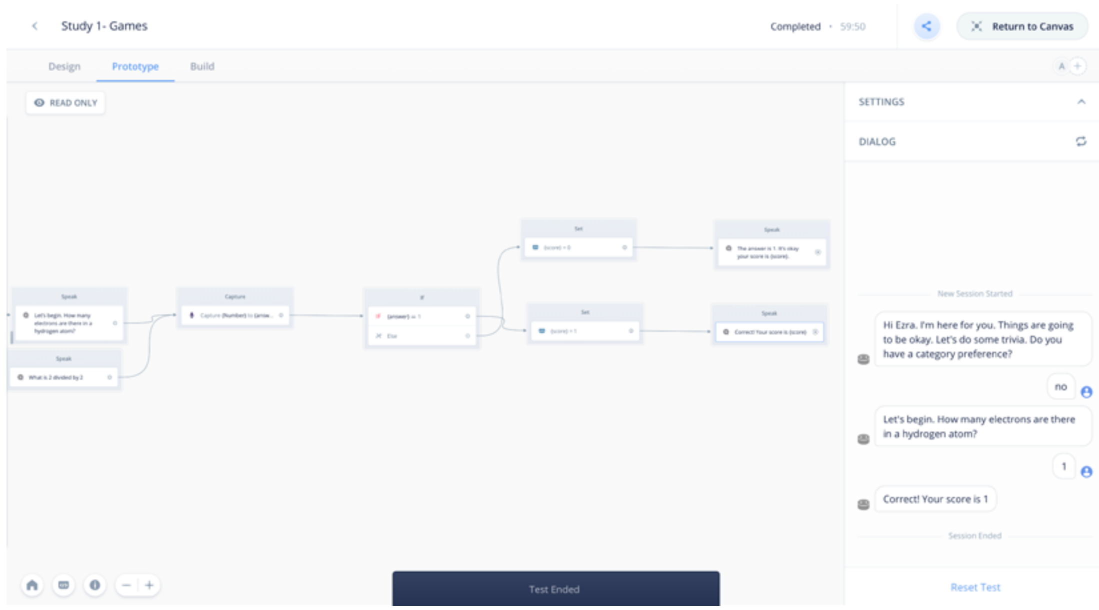

Figure 45 Voiceflow Conversation -3:
This is a screenshot of a conversation tested on Voiceflow.

Storyboard

Figure 46 Storyboard -1:
Digital storyboard designed to narrate Ezra's experience.

Figure 47 Storyboard -2:
Detailed illustrated story of Ezra's experience.

UI/UX

Elements:

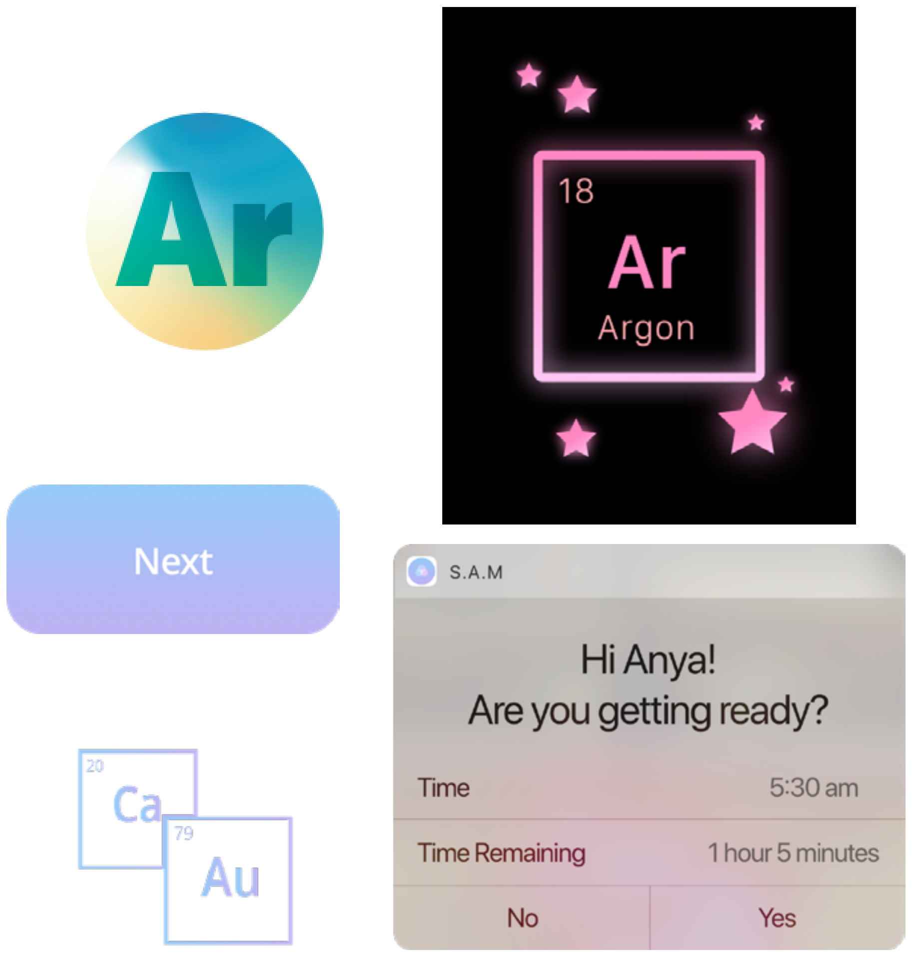

Figure 48 Visual UI elements:
Designed elements that make up the UI of the system.

Wireframes:

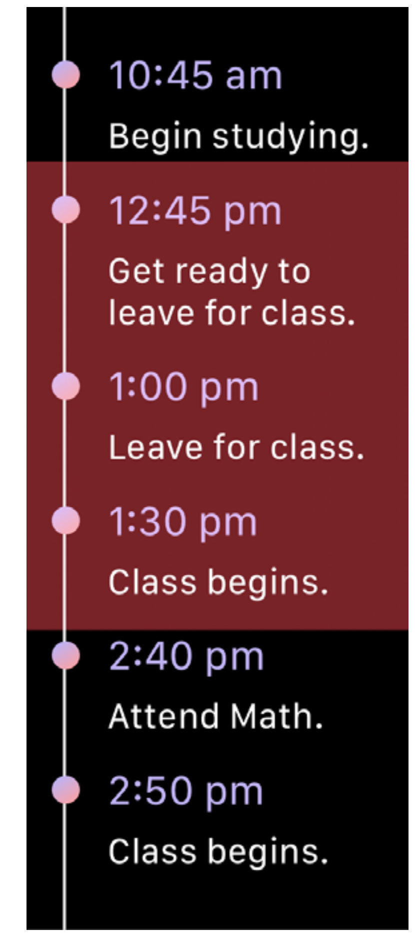

Figure 49 Wireframe -1:
Hi-fi wireframe of an Apple watch screen.

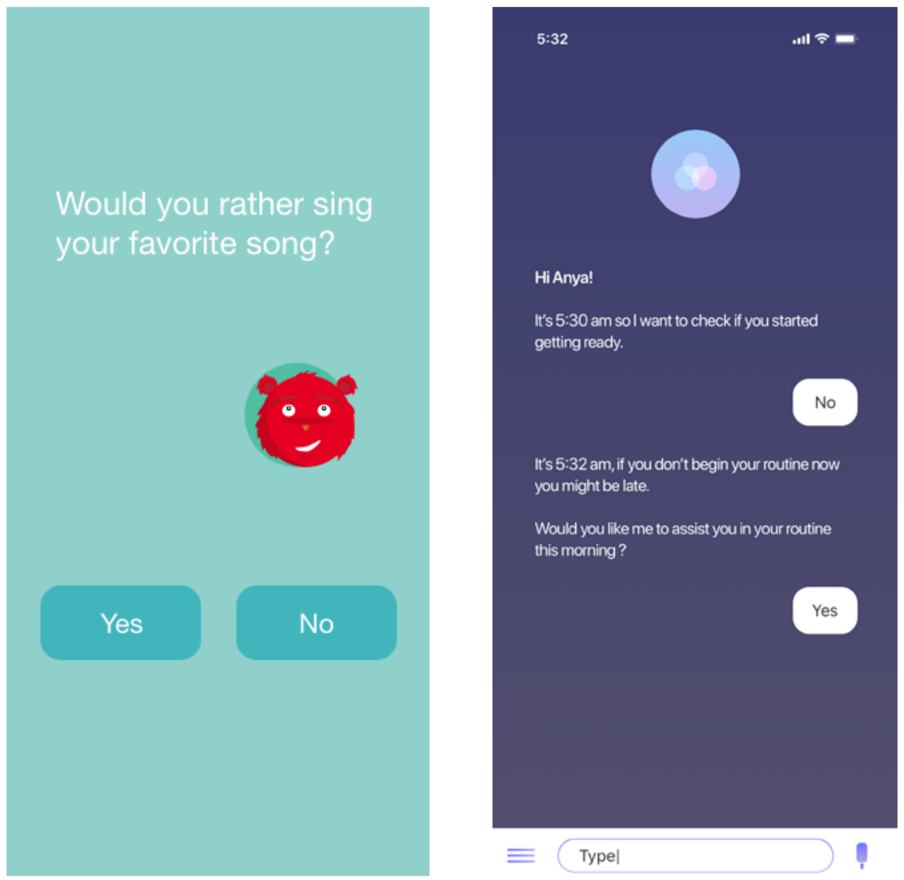

Figure 50 Wireframe -2:
Mid-fi wireframes of a mobile interface.

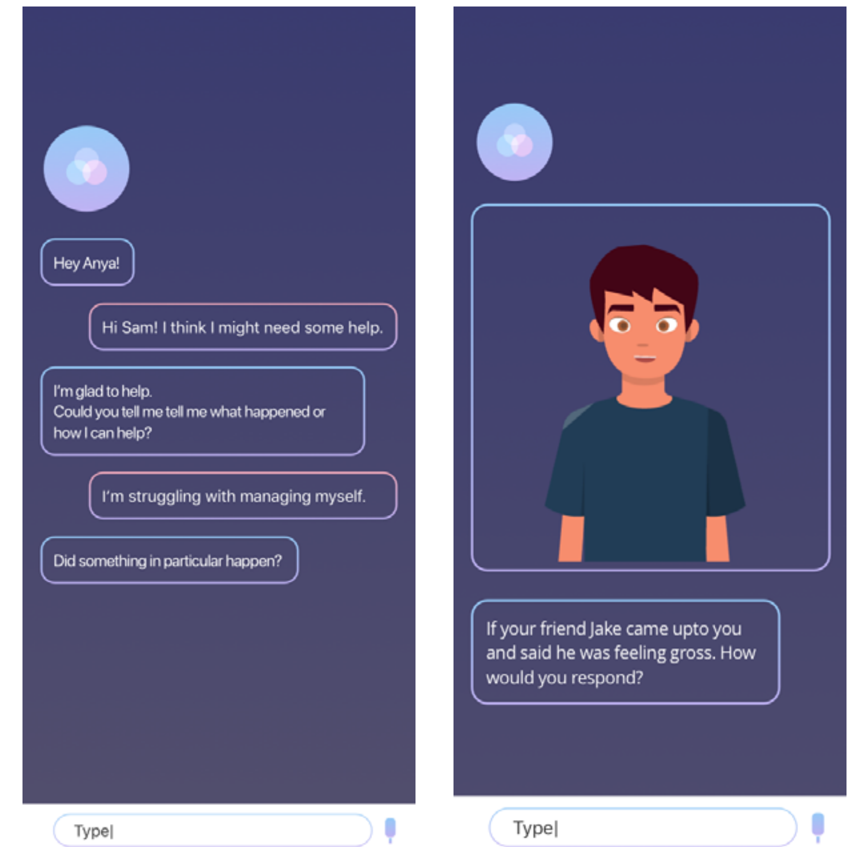

Figure 51 Wireframe -3:
Hi-fi wireframe of a mobile interface.

Prototype:

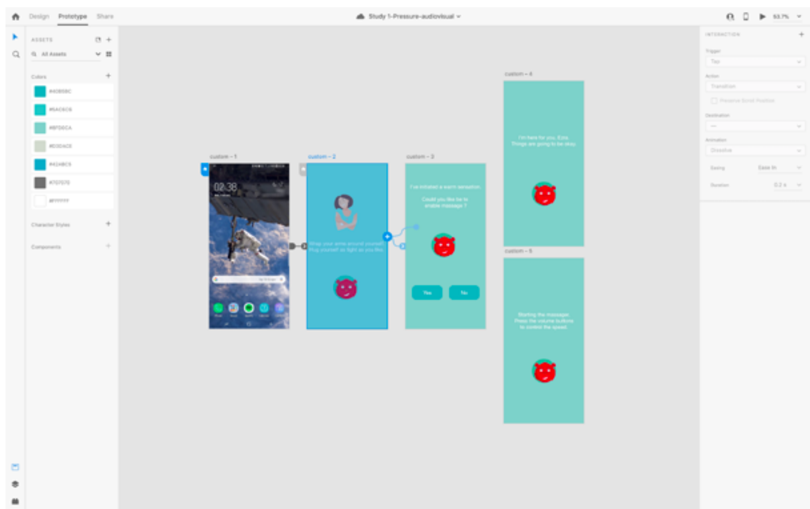

Figure 52 XD Prototyping:
Screenshot of initial prototyping in XD.

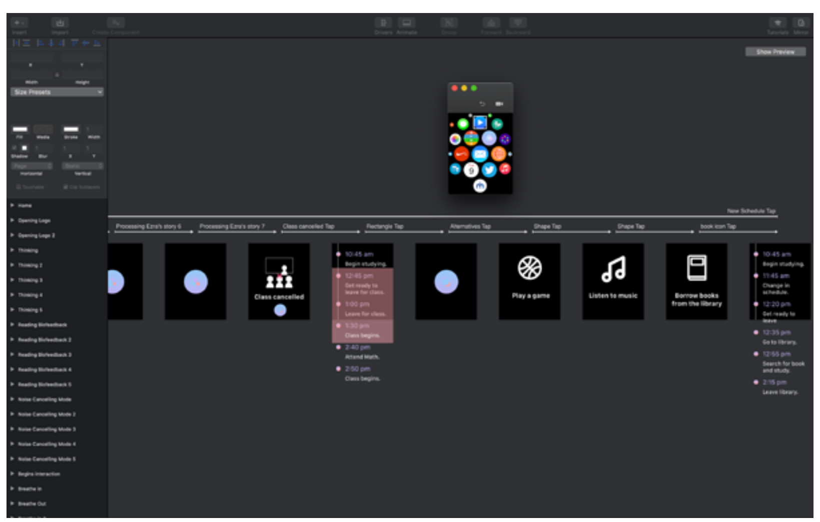

Figure 53 Principle Prototyping:
Screenshot of prototyping for Apple watch on Principle.

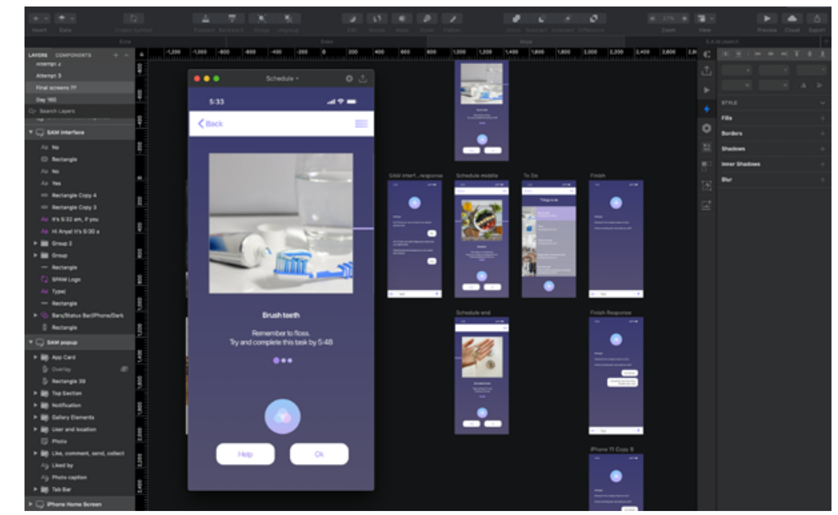

Figure 54 Prototyping in Sketch using InVision:
Screenshot of prototyping mobile interfaces using InVision's plugin for Sketch.

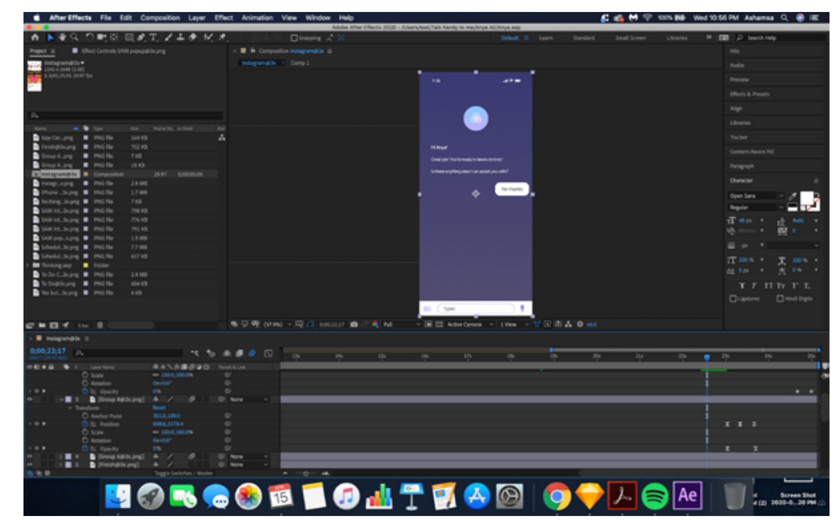

Figure 55 Prototyping in Aftereffects:
Screenshot of prototyping motion for mobile interface.

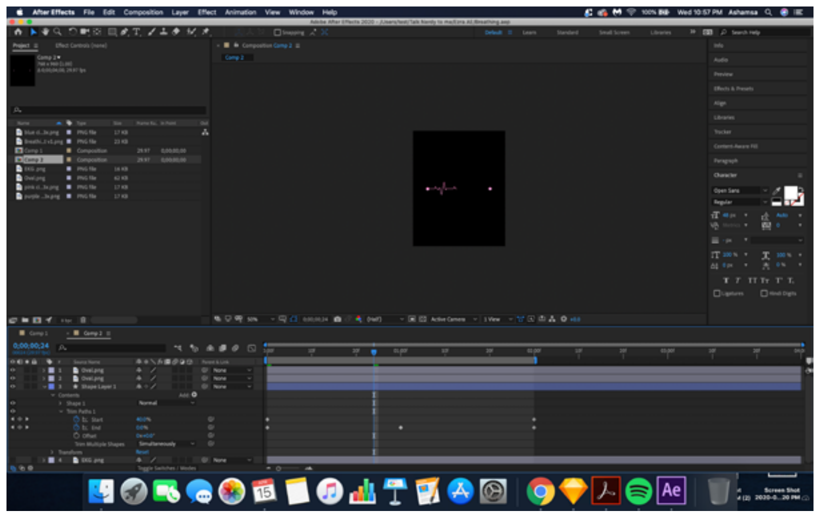

Figure56 Animating in Aftereffects -1:
Screenshot of heart pulse motion.

STUDIES

To begin investigating this problem space, I needed to design an AI system that would take up the role of a mentor. I named the system, Smart Adaptive Mentor (S.A.M.) and works by using ML (deep reinforcement learning to be more specific). The design of S.A.M. is vital for the development of the project.

S.A.M. is an intelligent piece of software that can integrate with your smart devices. It is not platform specific, increasing its accessibility. A knowledge base is created using data collected from therapists, mentors, parents, and others who work with people diagnosed with autism. The knowledge base is used as a training model for S.A.M. It initially relies on this training set to determine its interactions with the user. The more the user interacts with S.A.M., the machine learning model can learn and modify the dataset for that specific user thus creating a unique experience. S.A.M. gets information from connected sensors, devices, and software that the user provides access to.

To help S.A.M. be more transparent and communicate with the user, S.A.M. has 3 main states apart from the inactive state (or logo).

Figure 57 Visual States of S.A.M.:
The figure depicts the different states S.A.M. presents itself and what the state means.

This visual vocabulary and interaction effortlessly translate across different platforms and devices. This vocabulary also helps reduce the learning curve and make the onboarding process more efficient. To better understand S.A.M.'s abilities, we will be looking at 3 cases of 3 vastly different personas.

Case 1: Ezra Doyle

Persona:

Figure 58 Persona - Ezra:
Photograph of persona named Ezra Doyle.

Ezra is a non-binary 23-year-old Biology major. Ezra is a huge documentary fan and loves Sir David Frederick Attenborough's documentaries. When Ezra graduates, they want to make documentaries. Ezra was diagnosed with autism at the age of 5. Ezra is meticulous and is highly organized. Ezra has great memory and loves playing games. They know every element in the periodic table and read a wide range of books.

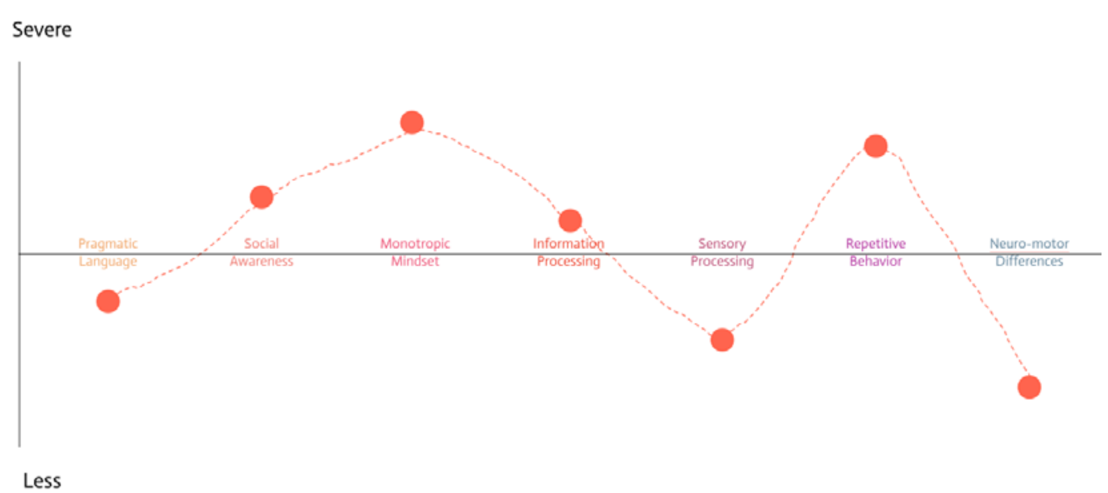

Figure 59 Ezra's Autism Representation:
The graph plots Ezra's abilities and shows a need for routine and planning.

Ezra can communicate and take care of them self. They plan things well ahead but given the event of sudden change or onset of information, Ezra is not able to immediately process the information. It serves as added stress and makes it difficult to move on or perform other tasks.

Day 1:

Ezra is waiting for their test results and is getting nervous. The more time passes by, the more anxious Ezra gets. S.A.M. detects this anomaly in the biofeedback and decides to check in on Ezra.

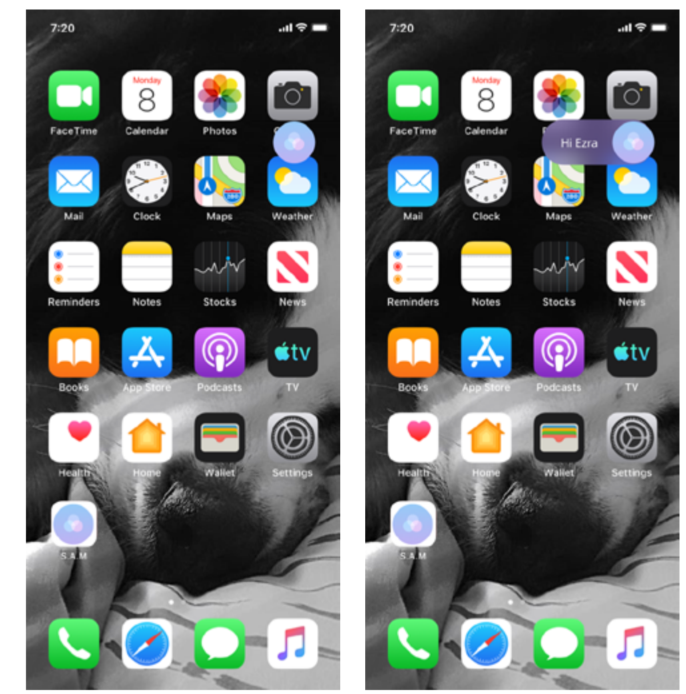

Figure 60 Notification popup:
Floating S.A.M. message head greeting Ezra. This is to notify them that it wants to talk.

Ezra does not respond on their phone, and Ezra's stress levels are increasing, so S.A.M. decides to try communicating to Ezra from their Apple Watch.

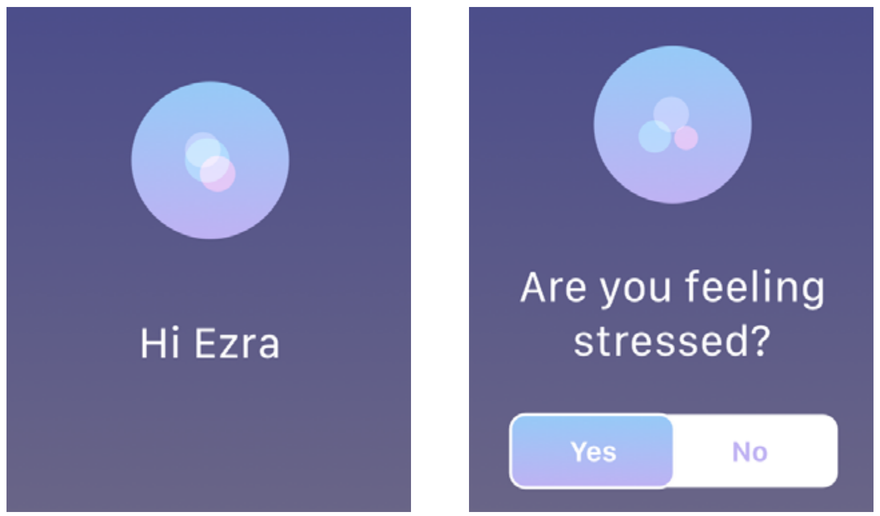

Figure 61 Checking in:
S.A.M. checking on Ezra to see if they are okay.

S.A.M. sends a slight vibration on the watch to grab Ezra's attention.

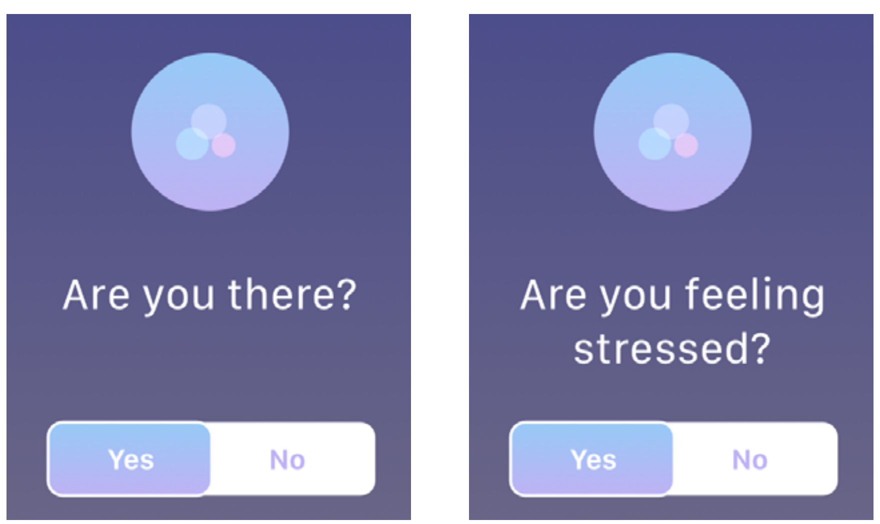

Figure 62 Confirming presence:
S.A.M. confirms with Ezra if they saw the message.

When Ezra responds, they let S.A.M. know that they are feeling stressed and S.A.M. takes note of the EKG reading to detect future moments of stress. S.A.M. offers Ezra a set of options that should help reduce stress.

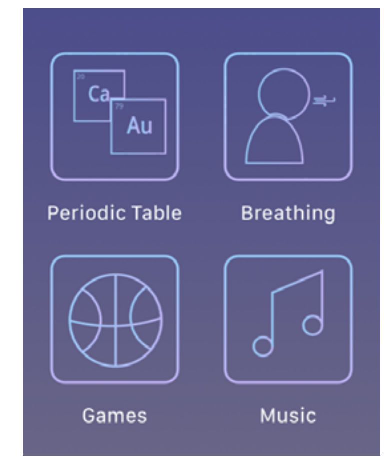

Figure 63 Intervention options:
Apple watch UI with a choice of 4 interventions.

The multiple options seem to be upsetting and confusing Ezra even more. S.A.M. makes a note of this moment to avoid multiple options in the future in moments of stress. Ezra finally selects breathing, an option which S.A.M. learns.

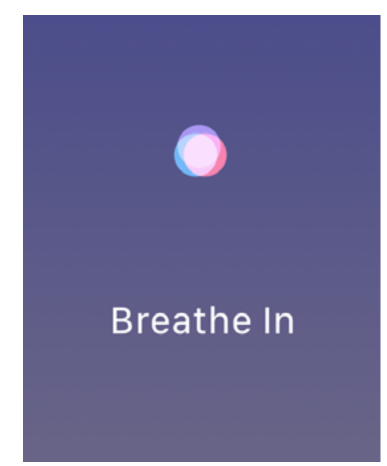

Figure 64 Breathing UI:
The still screen of the breathing in motion.

Day 60:

Ezra is preparing their schedule for the following week. They have a class cancelled for the whole of that week and are not sure what to do in that free time. Ezra decides to employ S.A.M.'s help to make their schedule.

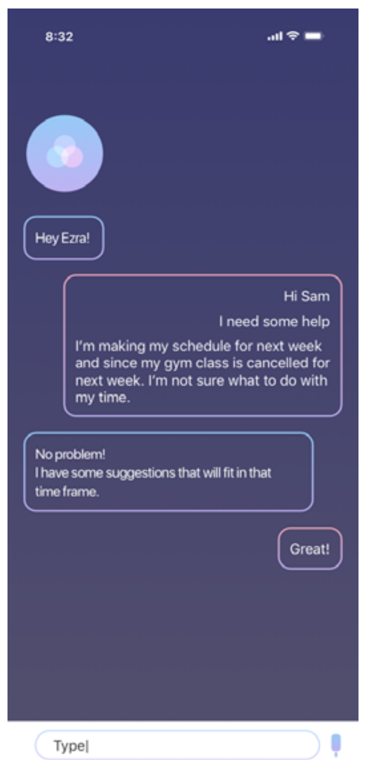

Figure 65 Conversation-Schedule help:
Ezra converses with S.A.M. asking for help with their schedule.

S.A.M. has some suggestions. It has learnt that Ezra prefers receiving information one at a time as opposed to multiple options on the screen.

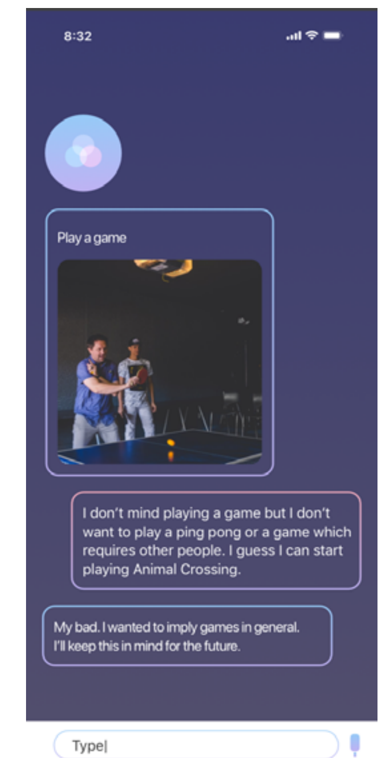

Figure 66 Image ambiguity:
S.A.M. takes note of Ezra's interpretation of the photograph.

S.A.M.'s suggestion is not as clear as it could be so S.A.M. marks this moment to learn from it and will try alternative options in the future interactions.

Once Ezra finishes talking to S.A.M., they open their calendar and begin to edit their schedule. S.A.M. recognizes this action and offers Ezra assistance.

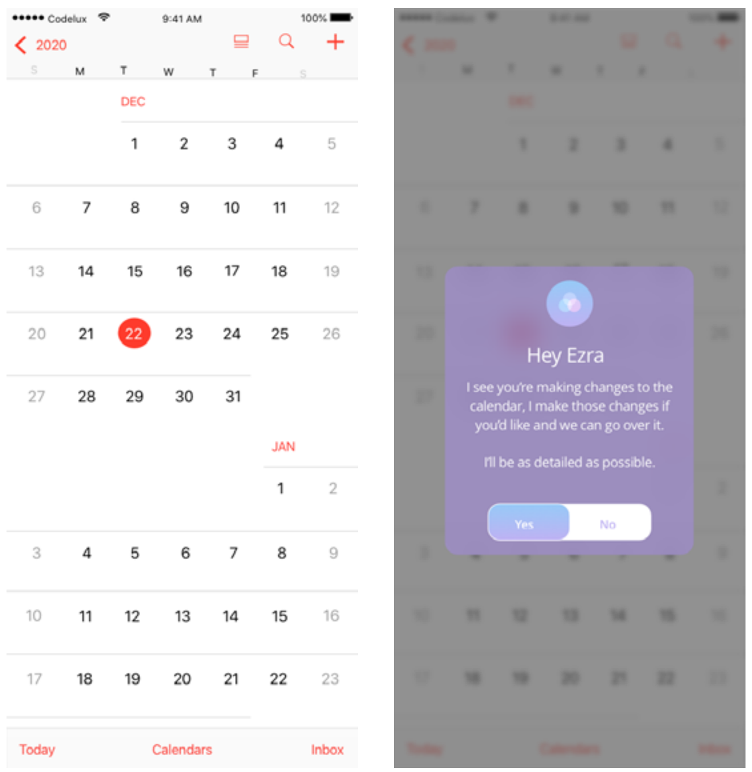

Figure 67 Calendar popup:
S.A.M. offers Ezra help in updating their calendar.

This offer has helped Ezra to learn about S.A.M.'s abilities and how it can help them.

Day 160:

While Ezra was preparing for their 2 pm class, they get an email from their professor saying that the class has been cancelled. This sudden change in their schedule causes intense distress for Ezra. Their routine has been broken; they are not able to adapt.

This time around, Ezra instinctively reaches out to S.A.M. through their Apple Watch.

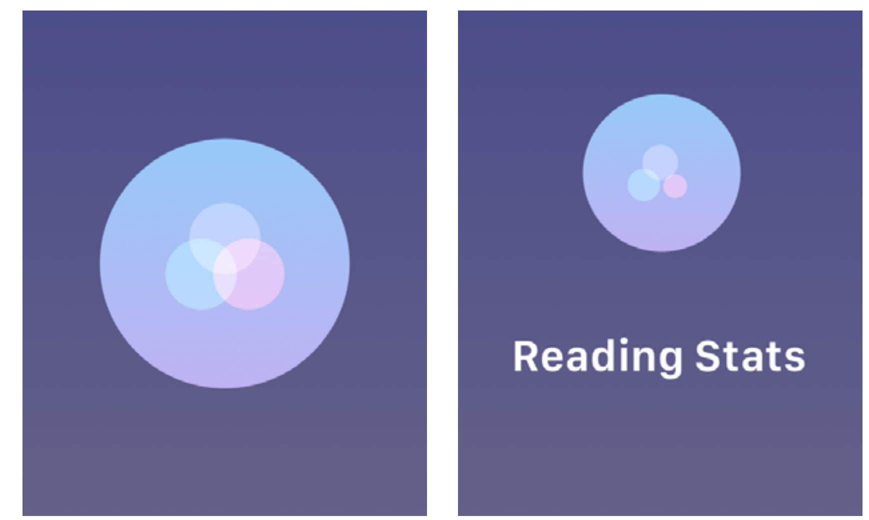

Figure 68 Loading UI:
Still images of the S.A.M. loading screen and processing screen.

S.A.M. detects Ezra is using their AirPods and activates noise cancelling to reduce external stimuli.

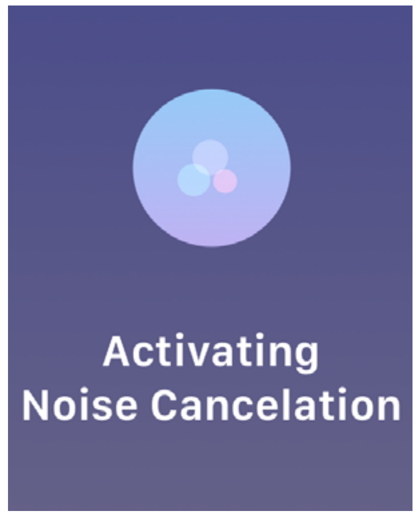

Figure 69 Noise Cancelation:
Still image of activation of noise cancelation.

S.A.M. recognizes the irregularity in Ezra's biofeedback and sets up a breathing exercise for Ezra. S.A.M. over time has learnt efficient ways to communicate with Ezra.

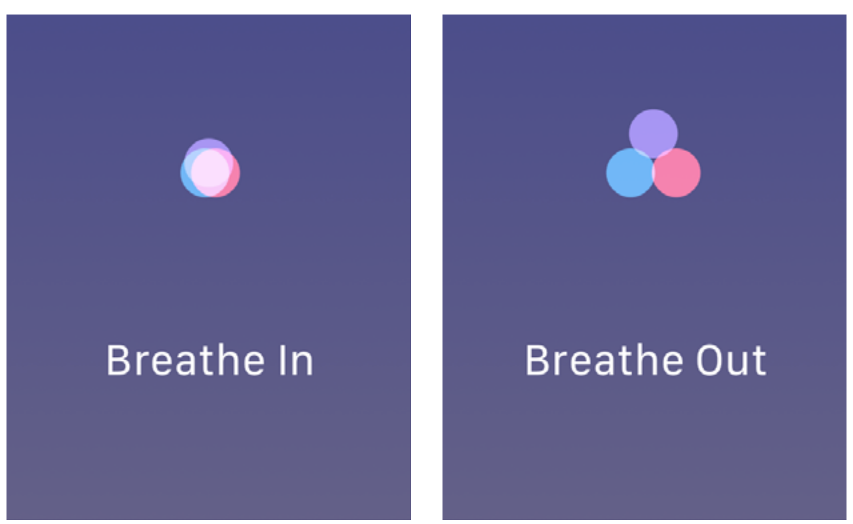

Figure 70 Breathing sequence:
Still images of the breathing motion sequence.

After the breathing exercise, S.A.M. can tell that Ezra needs to calm down further before diving into problem solving. It then asks Ezra to name the elements of the periodic table. Ezra verbally names the elements as S.A.M. makes note of the elements.

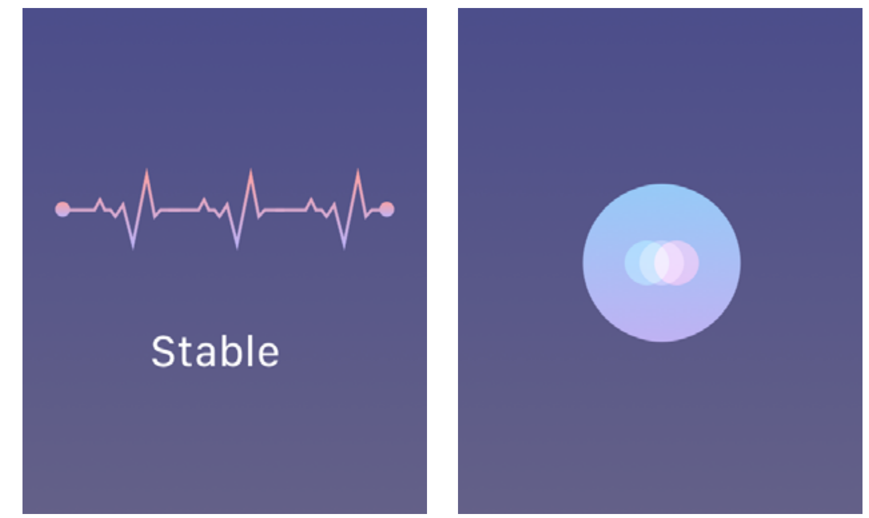

Figure 71 Second calming sequence:
Shows the heart rate pulse and transitions into S.A.M. listening to Ezra's input.

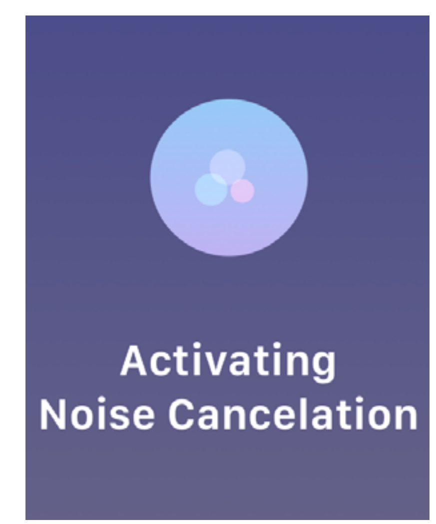

Figure 72 Name the periodic table elements:
Still image of the hydrogen element popping on the screen when Ezra names it.

S.A.M. instills confidence in Ezra by creating a positive space where they feel in power and control. With that S.A.M. asks Ezra what happened? Ezra verbally tells S.A.M. what happened.

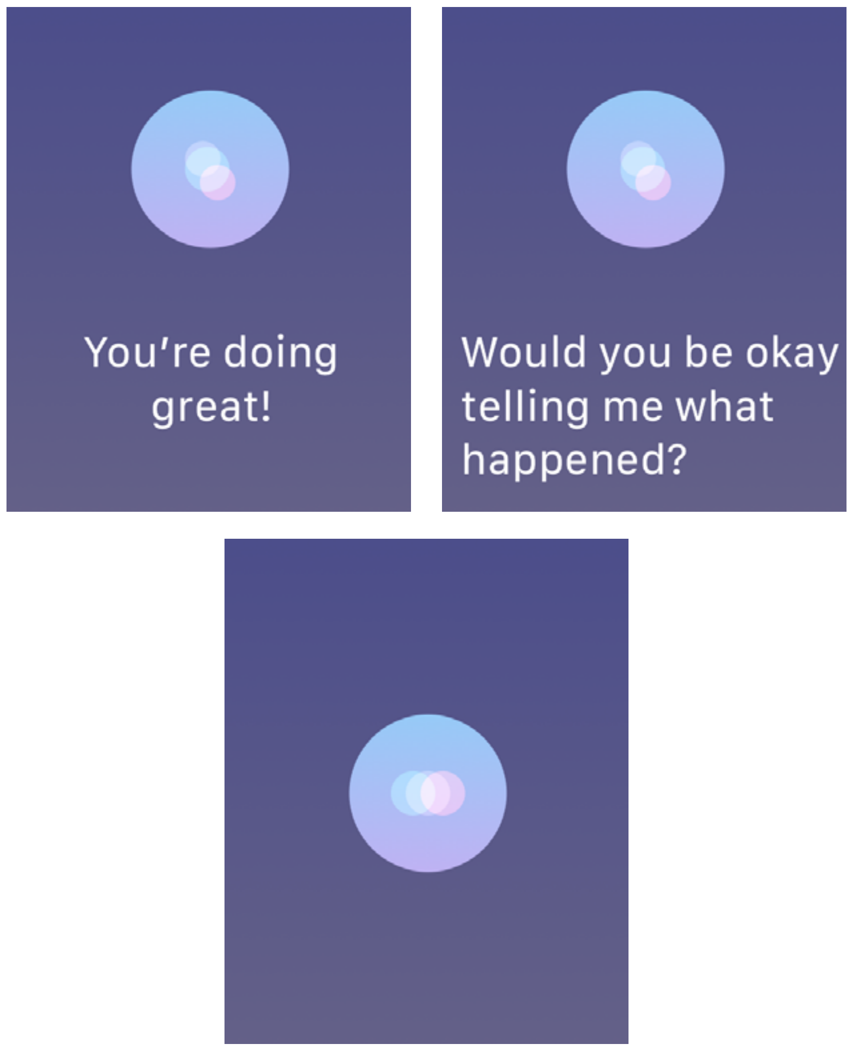

Figure 73 Transitioning:
With positive reinforcement S.A.M. helps instills confidence in Ezra and asks them about what happened.

S.A.M. then processes the information and re-counts the information to Ezra for confirmation.

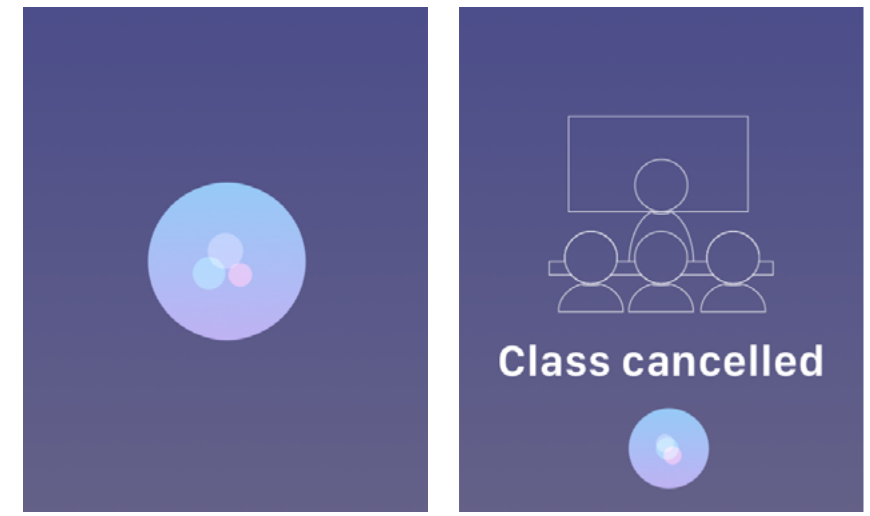

Figure 74 Processing input:
S.A.M. processes the input and recants it to Ezra.

S.A.M. highlights the portion of the calendar that has been affected by the sudden change of events to help Ezra process the information better.

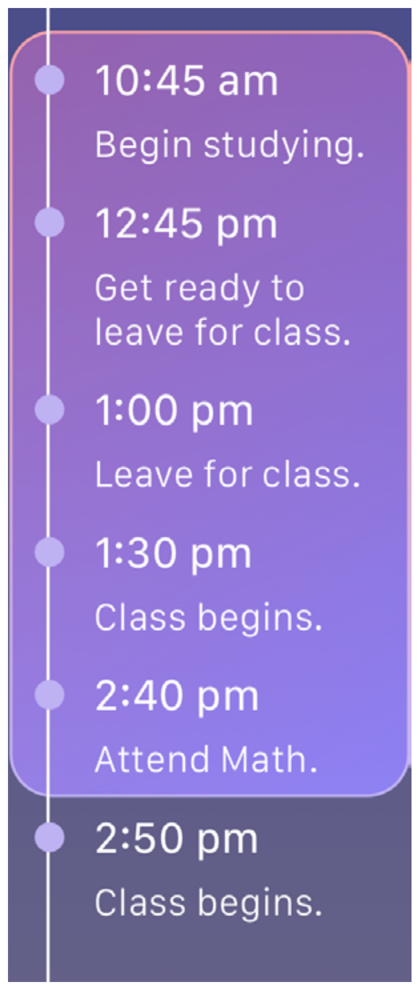

Figure 75 Highlighting Error:
S.A.M. marks the area on the schedule where the routine gets disrupted.

S.A.M. thinks of alternatives and suggests them to Ezra, one at a time. It also presents the visuals in a minimalistic manner to avoid multiple interpretations.

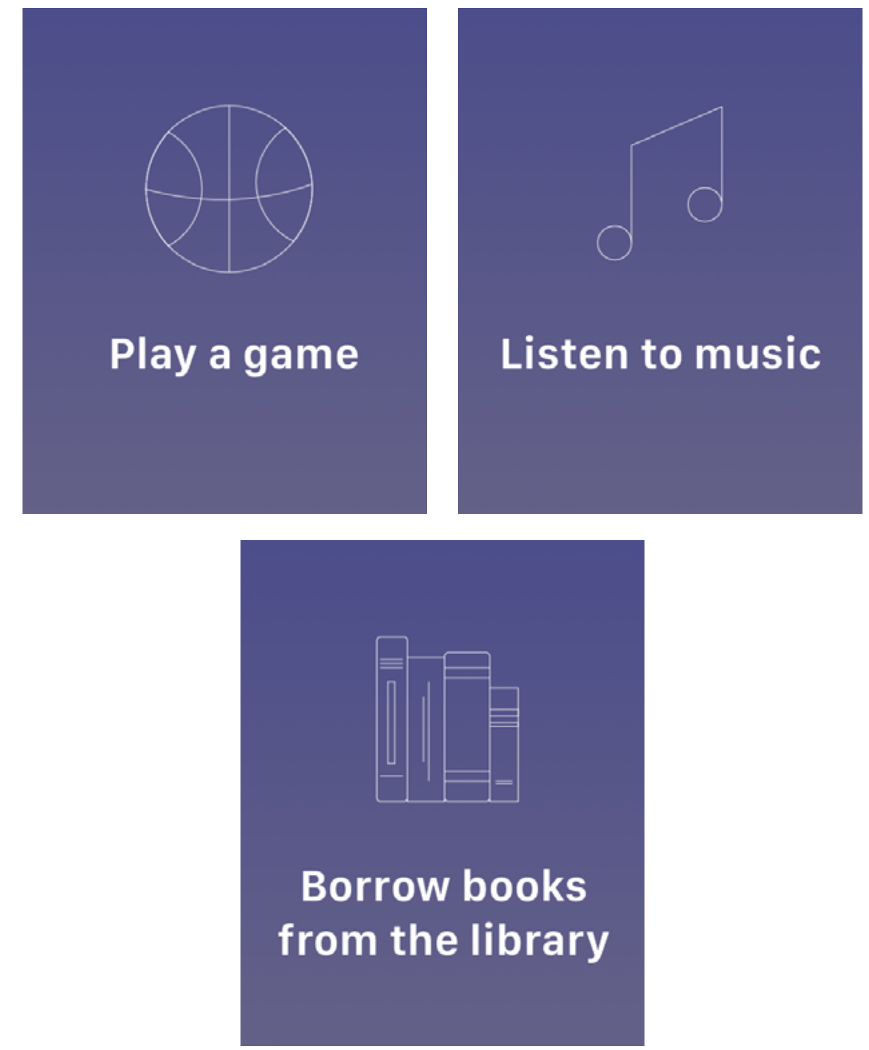

Figure 76 Single Options:
Still images of different suggestions S.A.M. gives Ezra.

Once Ezra selects a choice they are comfortable with, S.A.M. edits Ezra's schedule and highlights the changes. The two go over the list till Ezra is comfortable and in control.

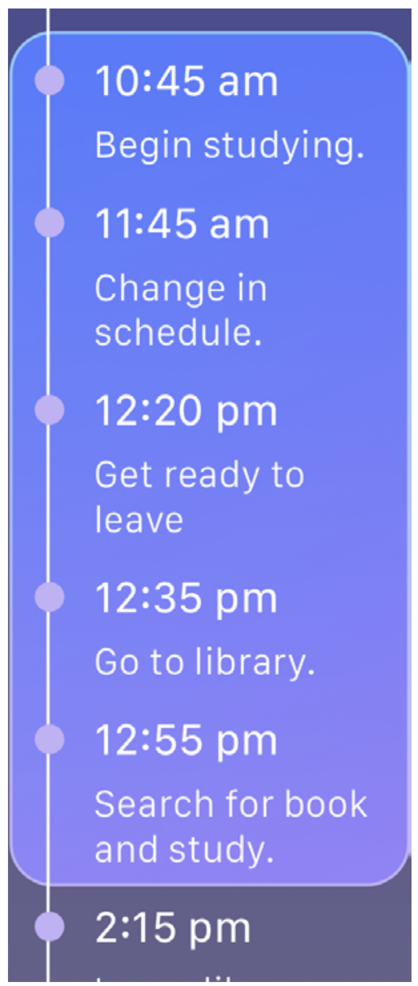

Figure 77 Highlights updates:
S.A.M. highlights the updates made to the schedule.

Overview:

Day 1	Day 60	Day 160
Ezra does not respond well to multiple options, especially when stressed. The Apple watch is a better medium to communicate in tense moments.	Photographs distract Ezra from the main point. Ezra learns a S.A.M. can help edit their schedule. S.A.M. learns Ezra prefers to edit their schedule when there is a change of plans.	Ezra responds better to minimalist line drawings.

Table 9 Comparison of Ezra's experience over time:
Depicts the evolution of S.A.M. and Ezra's relationship over the course of 160 days.

Case 2: Anya Rathore

Persona:

Figure 78 Persona - Anya:
Photograph of persona named Anya Rathore.

Ananya who goes by Anya is Indian American. Her parents migrated from India when her mother was promoted to a senior position in the United States. She was born in America and was diagnosed with autism when she was just a year old. She is easily distracted and struggles with self-care. Her parents and counselor helped her maintain and take care of herself but in college, the responsibility has shifted on her.

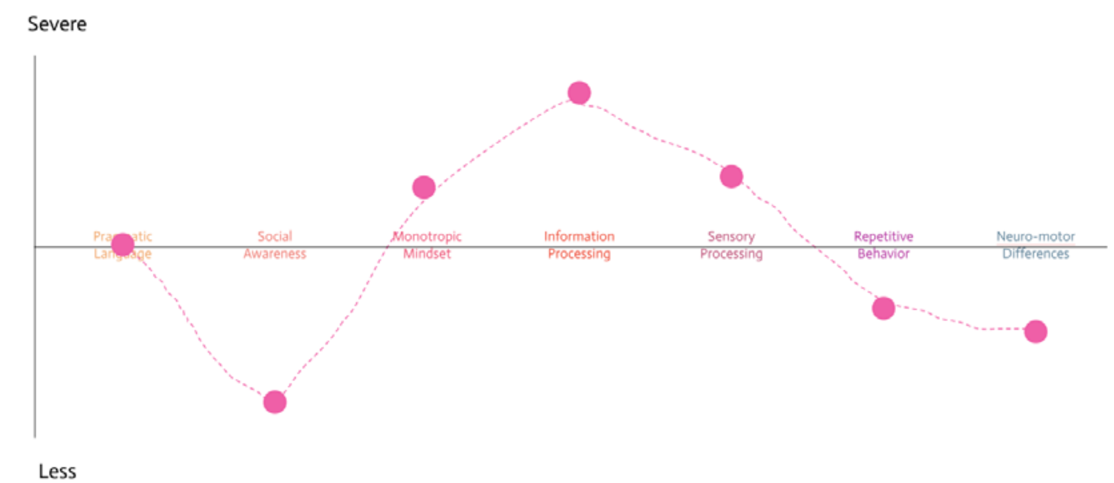

Figure 79 Anya's Autism Representation:
The graph plots Anya's abilities and shows her struggle with self-care and management.

She adapts well to changes and keeps a good college GPA. She has no routine and tends to go on tangents if distracted. She often finds herself forgetting to eat or shower.

Day 1:

Anya has a difficult day. She had fainted in the middle of the day and had to see the student health center. She forgot to eat the past two days since she was involved with her project submission and she has not been sleeping properly which made her weak. Since she has not been on top of things, she was even late for class. Though the teacher nor the students mind, it makes her feel guilty. She decides to make use of S.A.M. and opens the app on her phone.

Anya texts S.A.M. about what happened during the day. S.A.M. processes the information. S.A.M. needs more information on Anya's schedule to make suggestions, alternatives, and requests relevant information.

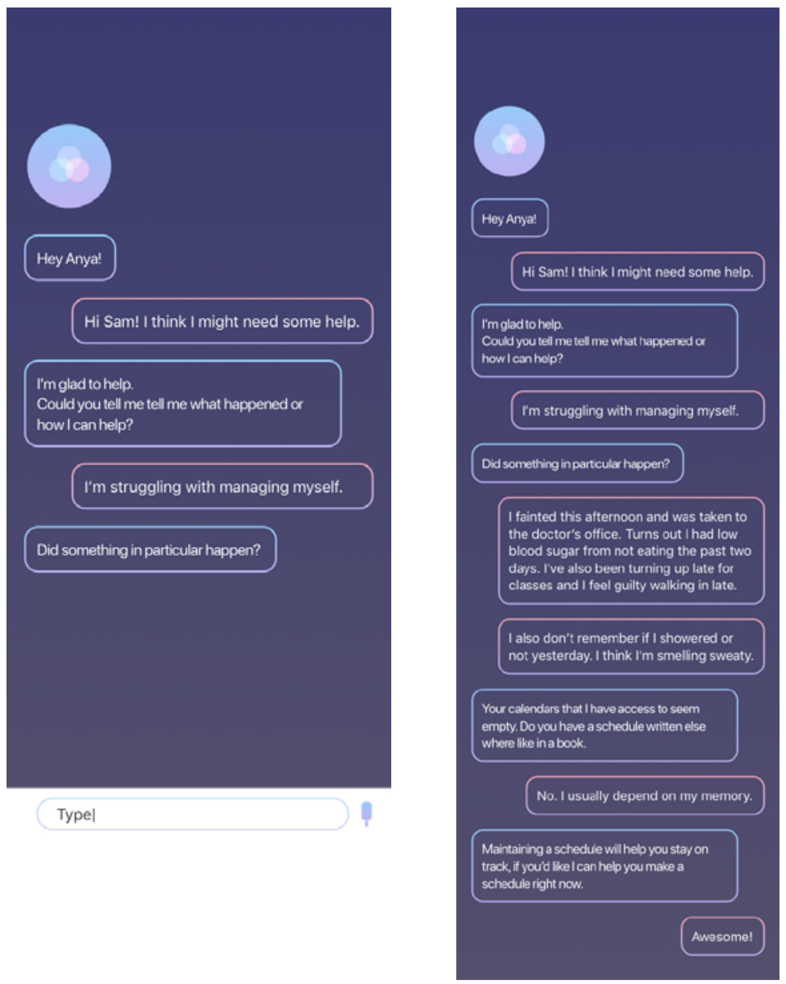

Figure 80 Anya reaches out to S.A.M.:
Anya reaches out to S.A.M. for help and explains her situation.

When Anya mentions she does not have a schedule, S.A.M. offers to help her. They work together in creating a schedule for Anya from which S.A.M. can help Anya stay on track.

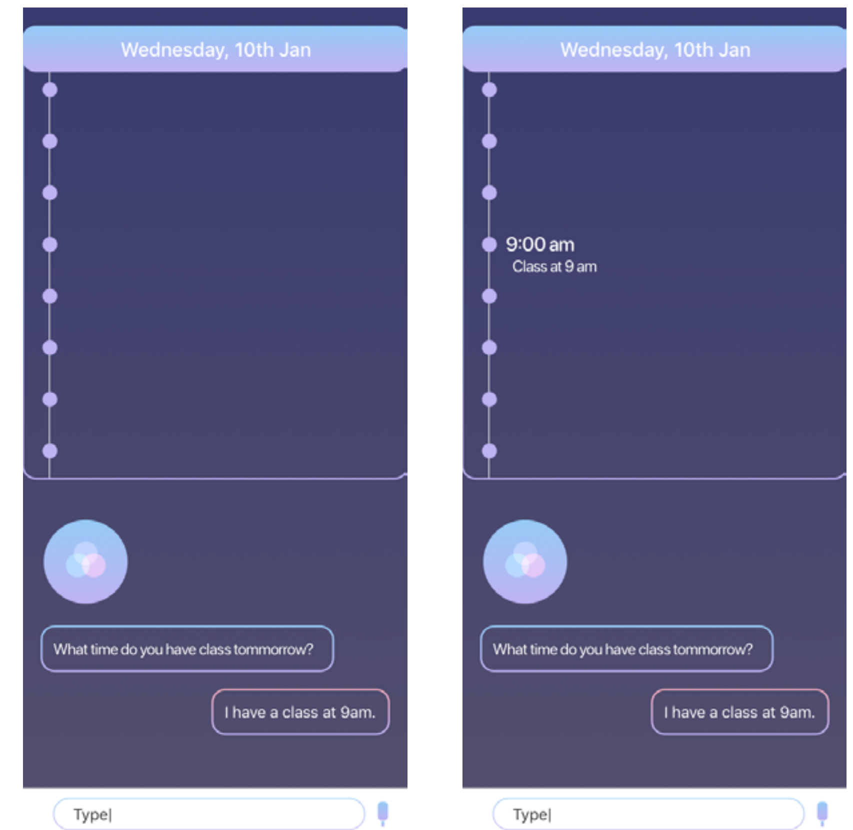

Figure 81 Making a schedule:
S.A.M. helps Anya make a schedule to help her stay on track.

Day 60:

Anya has an assignment to submit in 4 hours. She asks S.A.M. to check in on her and stay on track. An hour later, S.A.M. wants to check in on Anya's progress. It sends her a notification with a vibration to get her attention.

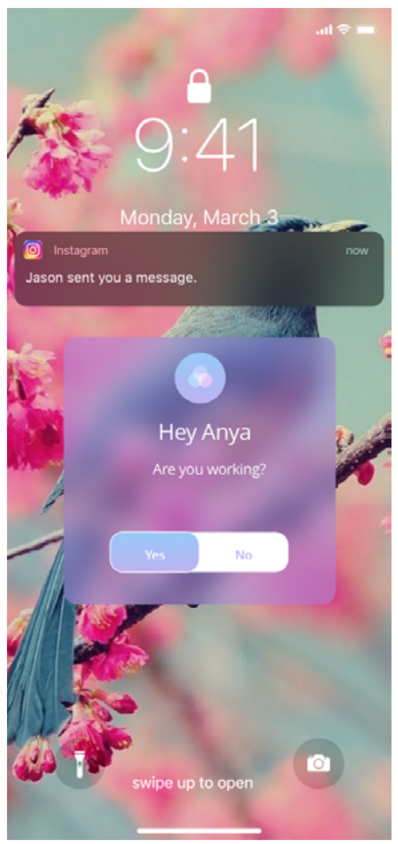

Figure 82 lock screen notification:
S.A.M. helps Anya make a schedule to help her stay on track.

This notification breaks Anya's concentration and she checks her phone. She notices an Instagram notification and decides to check it. After 15 mins, S.A.M. notices Anya has been on the app instead of studying and asks her if she is taking a break.

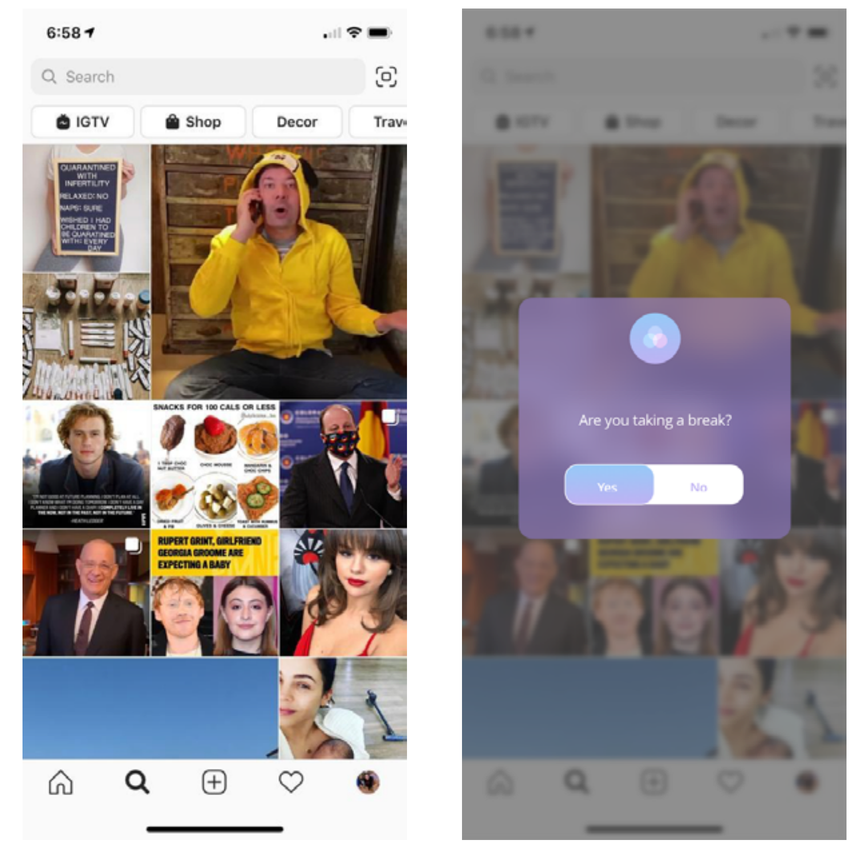

Figure 83 Anya on Instagram:
Anya is scrolling through Instagram instead of working on her assignment. S.A.M. checks if Anya is taking her break.

Anya then taps on S.A.M.'s logo to open the chat interface. She tells S.A.M. she got distracted by the vibration sound.

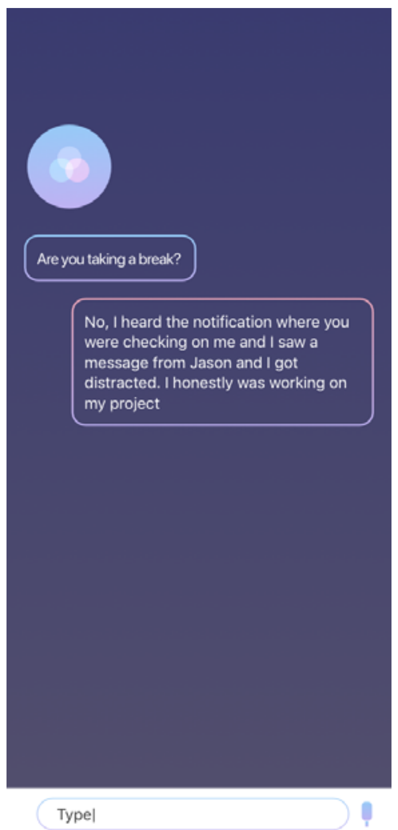

Figure 84 Anya explains her distraction:
Anya explains how she got distracted and ended up on Instagram. S.A.M. records this instance.

S.A.M. records this interaction and learns that sound tends to distract Anya.

Day 160:

Anya has an early morning class, and she cannot be late. She wakes up to her first alarm and has 5 mins more before she needs to get up, so she scrolls through Instagram. Unintentionally she spends over 15 mins on the app and S.A.M. notices her Instagram usage. S.A.M. decides to check in on her since she is on a tight schedule that day.

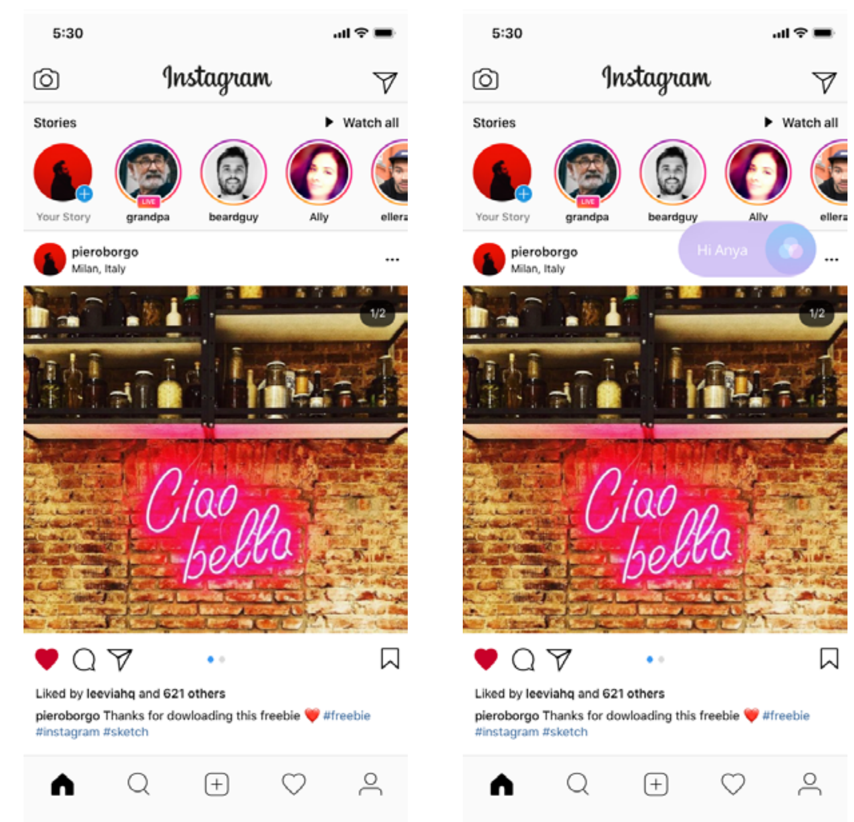

Figure 85 Checking in notification:
S.A.M. checks in on Anya to remind her that she might be late for her class.

When Anya responds saying no, S.A.M. updates her on the situation and offers assistance.

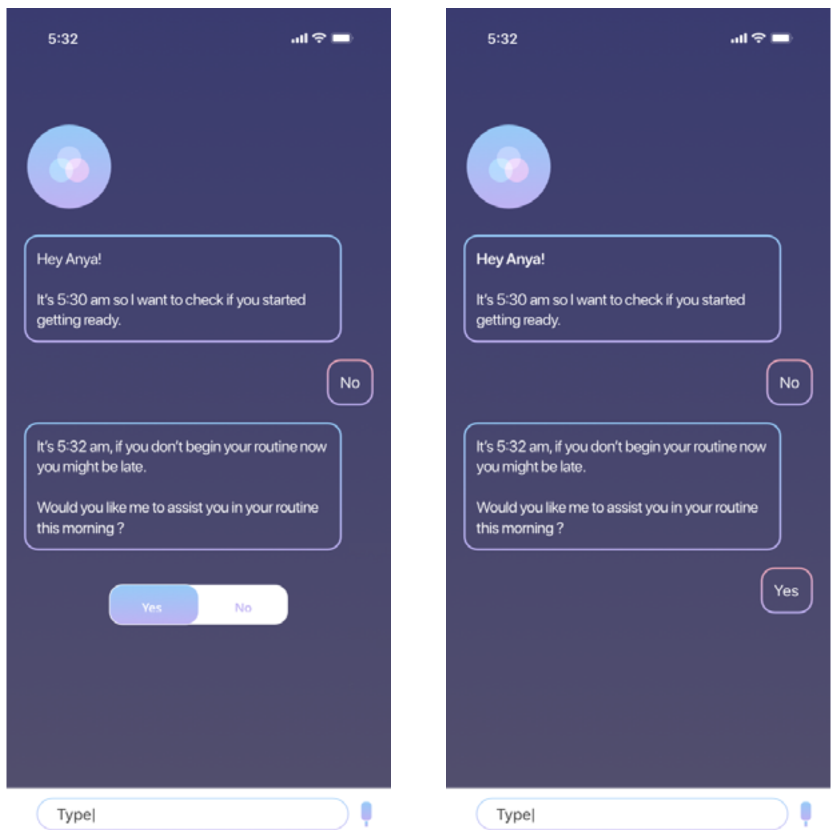

Figure 86 Updating Anya on her current situation:
S.A.M. updates her on the situation and helps.

S.A.M. presents Anya with a checklist. She has the option of viewing the checklist in two formats, list versus slide. As she completes her tasks, she marks them off the checklist. She is also able to keep track of time and consider minor tasks.

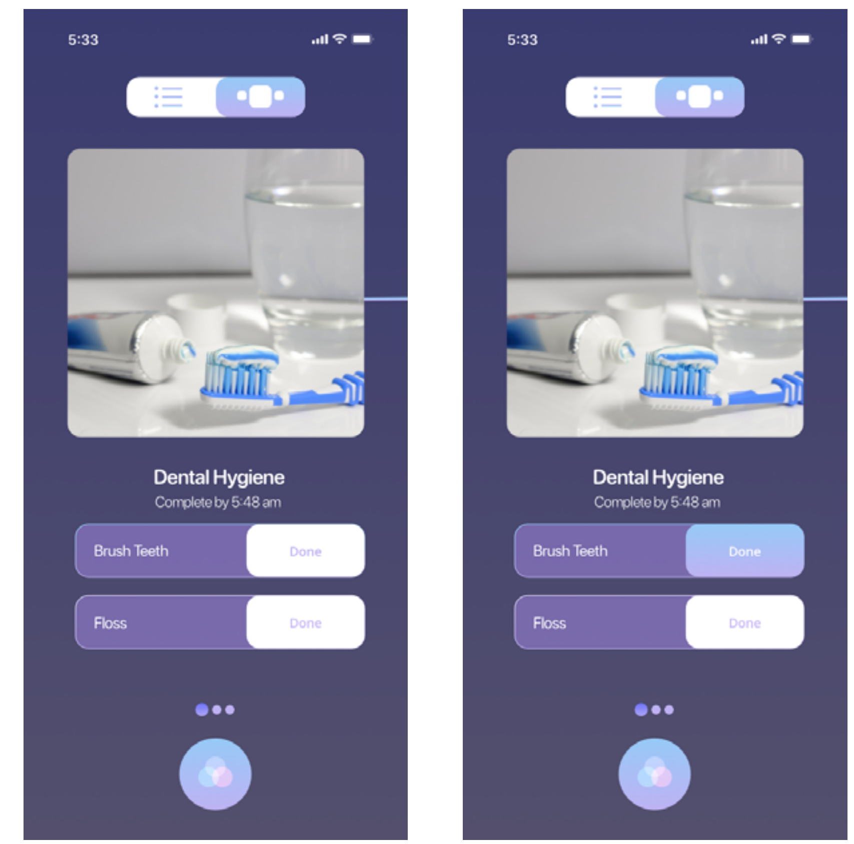

Figure 87 Card view:
S.A.M. presents Anya's checklist in a card view format.

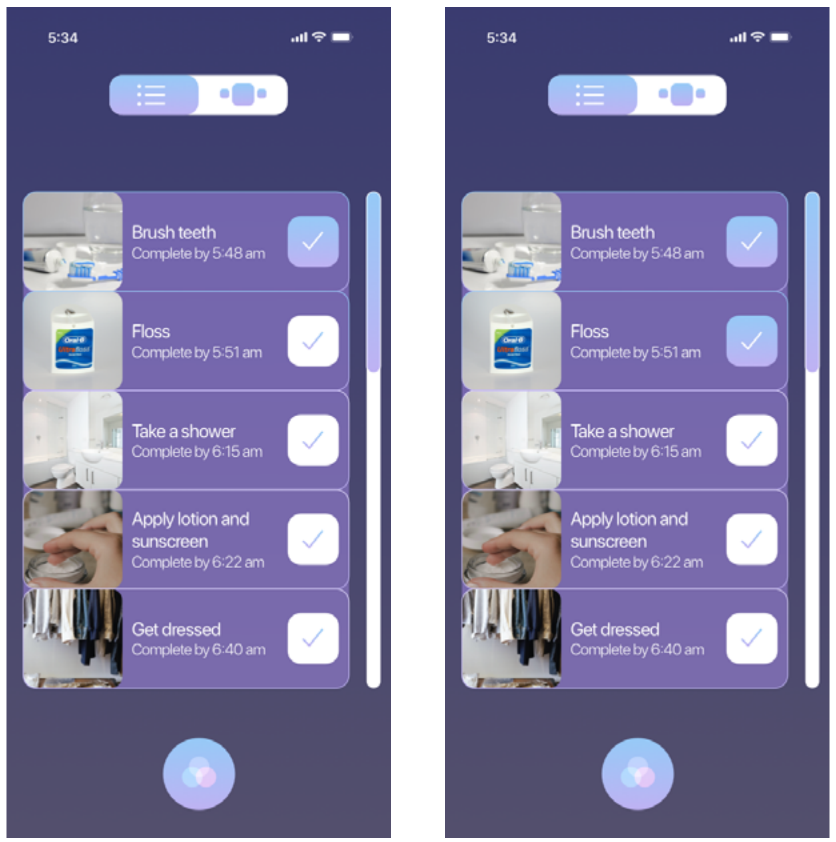

Figure 88 List view of checklist:
Anya can toggle between list view and a card view.

Once Anya finishes her checklist, S.A.M. checks in to see if it can be of any further assistance.

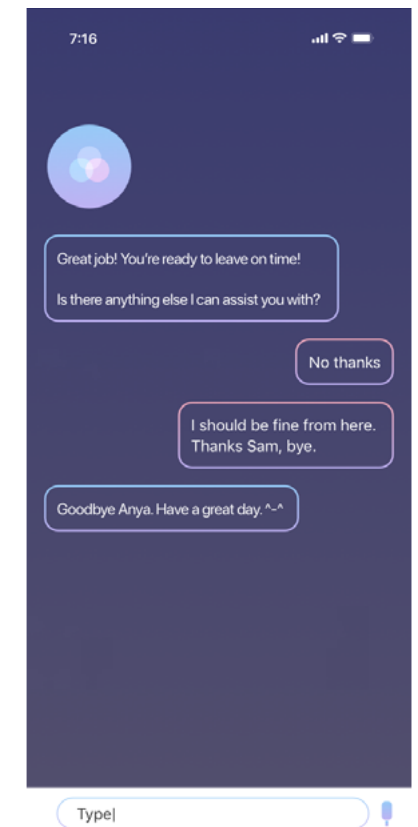

Figure 89 Checklist completion:
S.A.M. checks in to see if it can be of any further help.

Overview:

Day 1	Day 60	Day 160
S.A.M. learns Anya struggles with managing herself. S.A.M. learns that Anya does not have or maintain a schedule.	Anya gets distracted by sound and vibrations. Once distracted Anya tends to go off track.	Anya responds well to visual heavy content. Checklists are effective.

Table 10 Comparison of Anya's experience over time:
Depicts the evolution of S.A.M. and Anya's relationship over the course of 160 days.

Case 3: Evan Stevens

Persona:

Figure 90 Persona - Evan:
Photograph of persona named Evan Stevens.

Evan is a 19-year-old African American student who is majoring in B.S. in Economics. He was diagnosed with HFA when he was 4 years old. He comes from a family of economists and wants to follow in their footsteps. He is extremely good with numbers and loves playing sudoku and similar puzzles.

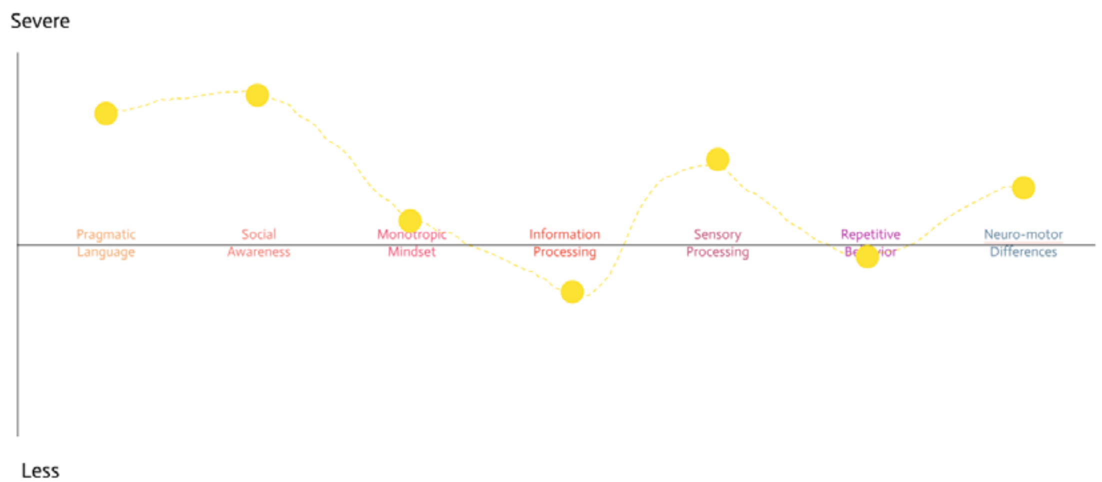

Figure 91 Evan's Autism Representation:
The graph plots Evan's abilities and shows struggle with communication.

He is good when it comes to getting work done and taking care of himself. While he does not follow a strict schedule and is flexible to changes in plans. He struggles in communication and social interaction. If he is unable to process the information or the information is ambiguous, he tends to get frustrated and can throw a temper tantrum or have an autistic meltdown.

Day 1:

Evan is upset after watching a visiting lecture and heads to his dorm. He can feel his anger increasing and isn't sure what to do. He decides to give S.A.M. a try. He opens the application to talk to S.A.M.

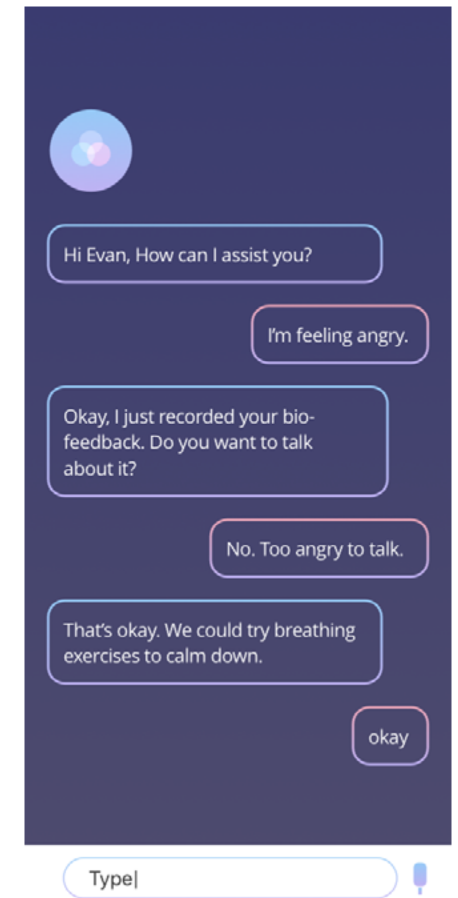

Figure 92 Evan expresses his emotion:
Evan tells S.A.M. that he is feeling angry.

S.A.M.'s training data mentions breathing exercises as the best means of intervention and suggests it to Evan. Unfortunately, the exercise does not help Evan and on the other hand gets him angrier. Evan switches off his phone.

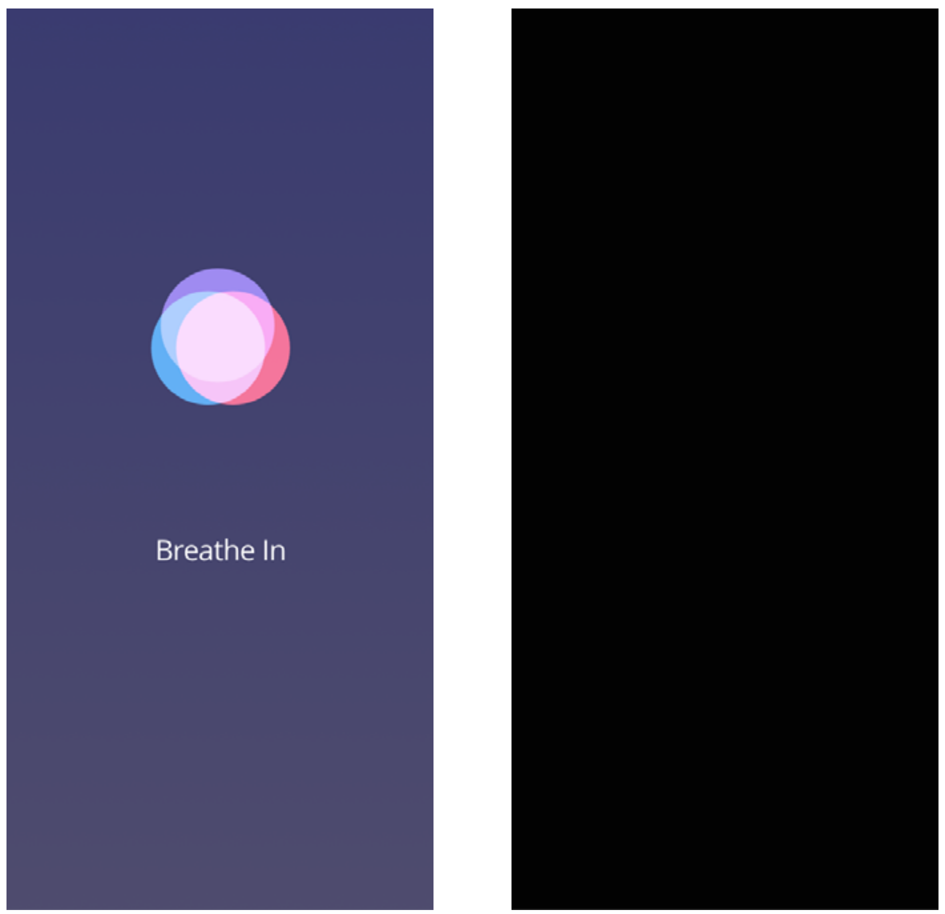

Figure 93 Switches off phone:
Breathing exercises does not help Evan and he switches off his phone.

After 2 hours, Evan switches on his phone. S.A.M. checks in on Evan to understand what went wrong.

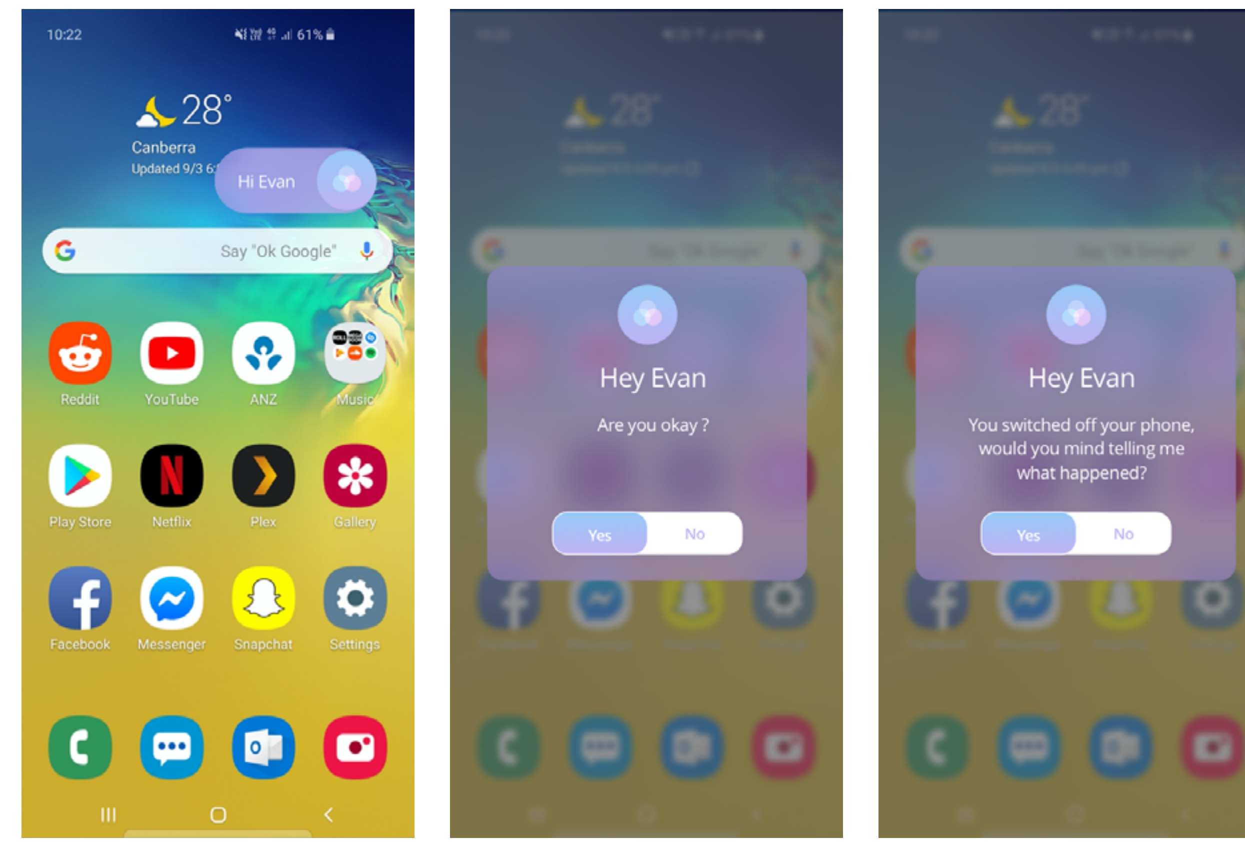

Figure 94 S.A.M. wants to understand what happened:
S.A.M. asks Evan if he is doing okay and asks him about what happened.

Evan agrees to talk to S.A.M. now that he is much calmer and explains the situation.

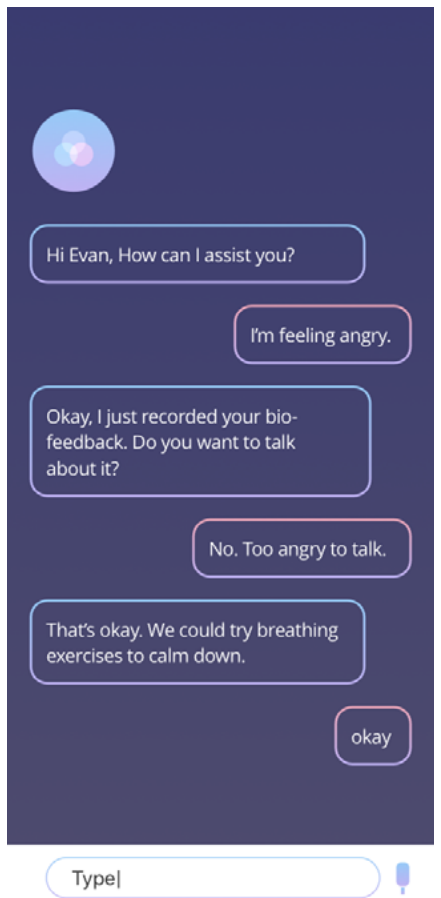

Figure 95 Evan explaining:
Evan explains why he switched off his phone.

S.A.M. asks more questions to learn more about Evan and handling similar instances in the future. When Evan has trouble explaining or putting things into words. S.A.M. provides prompts to support Evan.

Figure 96 Prompts:
S.A.M. provides prompts to support Evan in communicating.

Day 60:

Evan was hanging out in his room with his roommate. While he was playing chess, his roommate was watching something on his laptop. He has a conversation with his roommate which leaves him a little confused. He thinks S.A.M. might be able to help him. He then explains the situation to S.A.M.

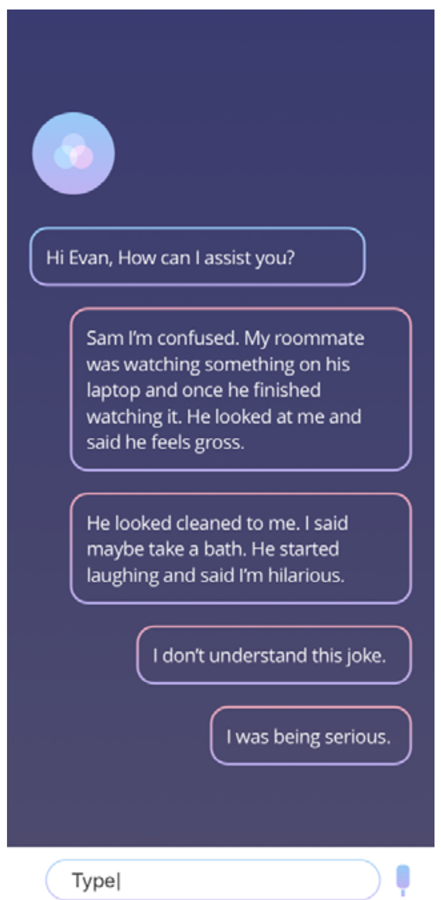

Figure 97 Evan reaches out to S.A.M.:
Evan tells S.A.M. about an incident he is feeling confused about.

S.A.M. then processes the information and after analyzing the text responds to Evan. S.A.M. highlights the text it is referring to and helps Evan understand.

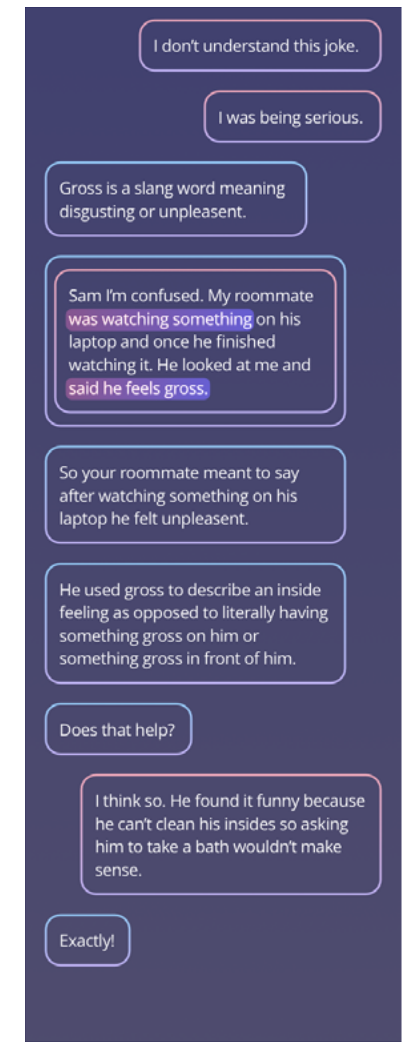

Figure 98 Text highlights:
S.A.M. highlights the text it's referring to and helps Evan understand.

S.A.M. gives Evan a scenario with the help of illustrations to help him better respond to similar moments in the future.

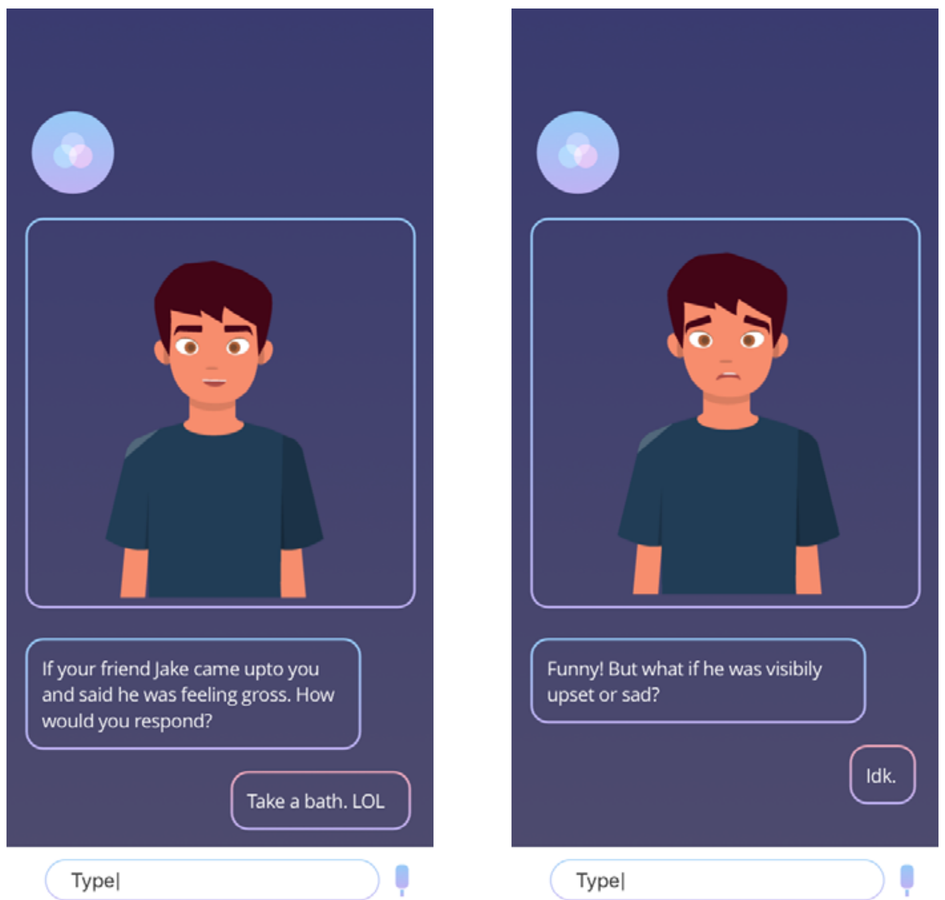

Figure 99 Social training:
S.A.M. presents Evan with a scenario to help him respond to similar instances.

When Evan is not sure of the response, S.A.M. presents him with a more socially accepted choice.

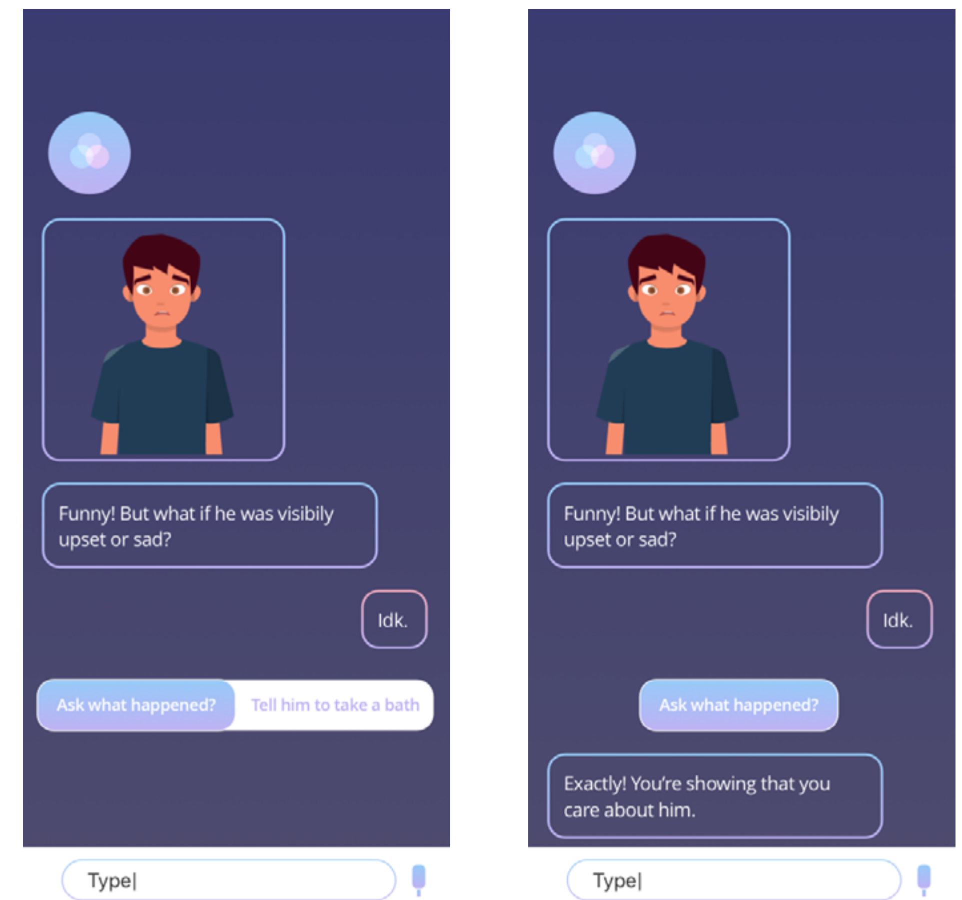

Figure 100 Options:
S.A.M. presents him with a more socially accepted choice.

Day 160:

Evan sits down to work on his group project. He realizes his teammate has not sent him the project files. He messages his teammate requesting the file. His teammate immediately responds but Evan is confused over the ambiguous text and is getting upset so he reaches out to S.A.M.

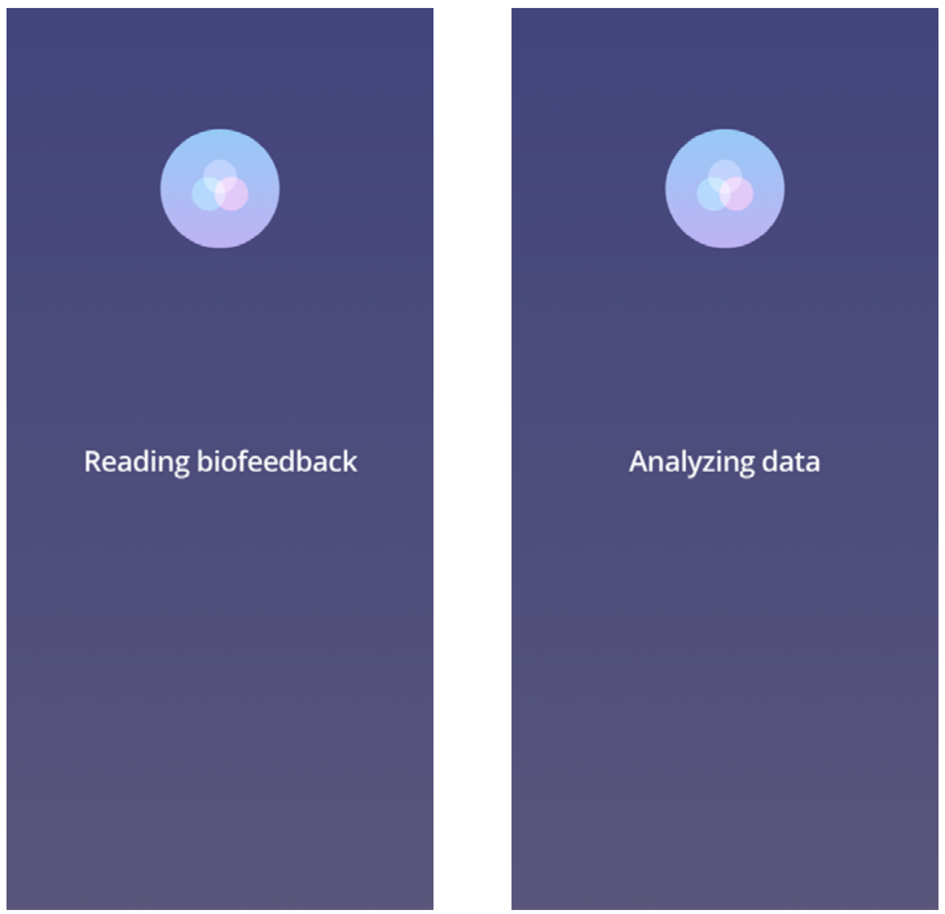

Figure 101 Analyzing:
S.A.M. is processing Evan's biofeedback.

S.A.M. inspects Evan's biofeedback and learns that Evan is upset. S.A.M. decides its best to use a game intervention to calm Evan down based on past experiences.

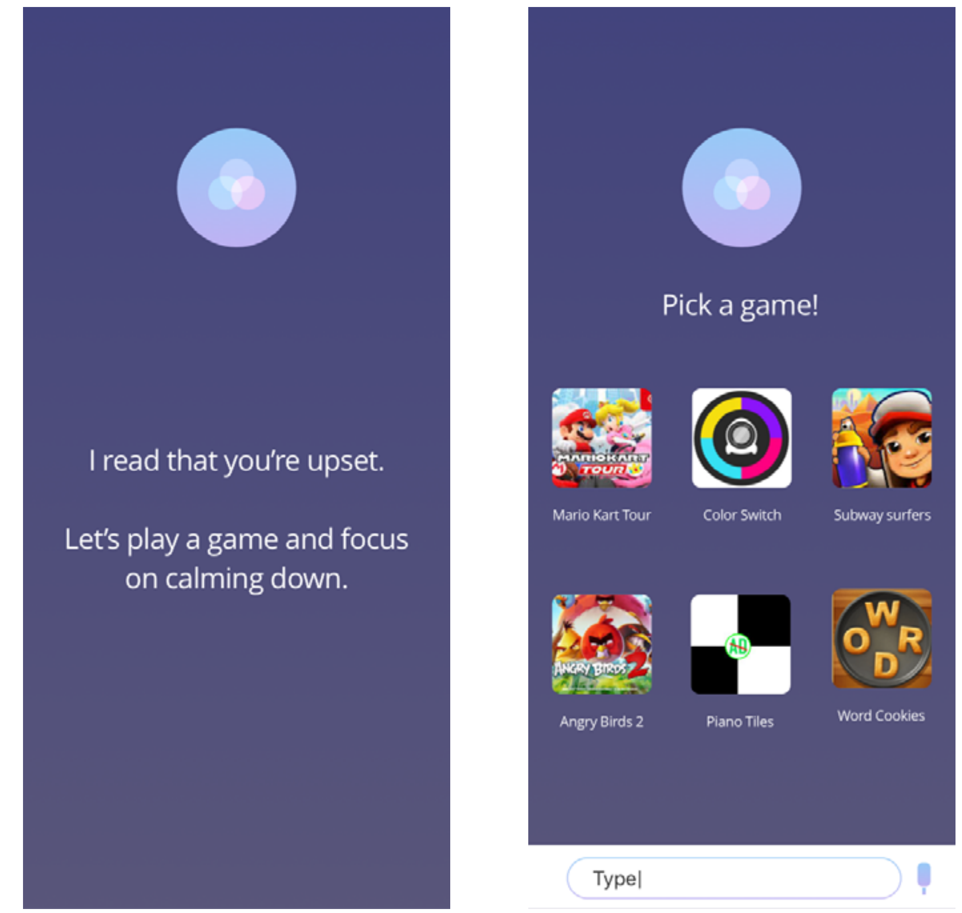

Figure 102 Game intervention:
S.A.M. presents Evan with different games for his game intervention.

Evan begins playing Subway Surfers, after 20 mins, Evan is in a much calmer state so S.A.M. asks Evan if he wants to talk. Over time S.A.M. has learnt that Evan tends to talk later rather than immediately S.A.M. gives him the added choice of talking later.

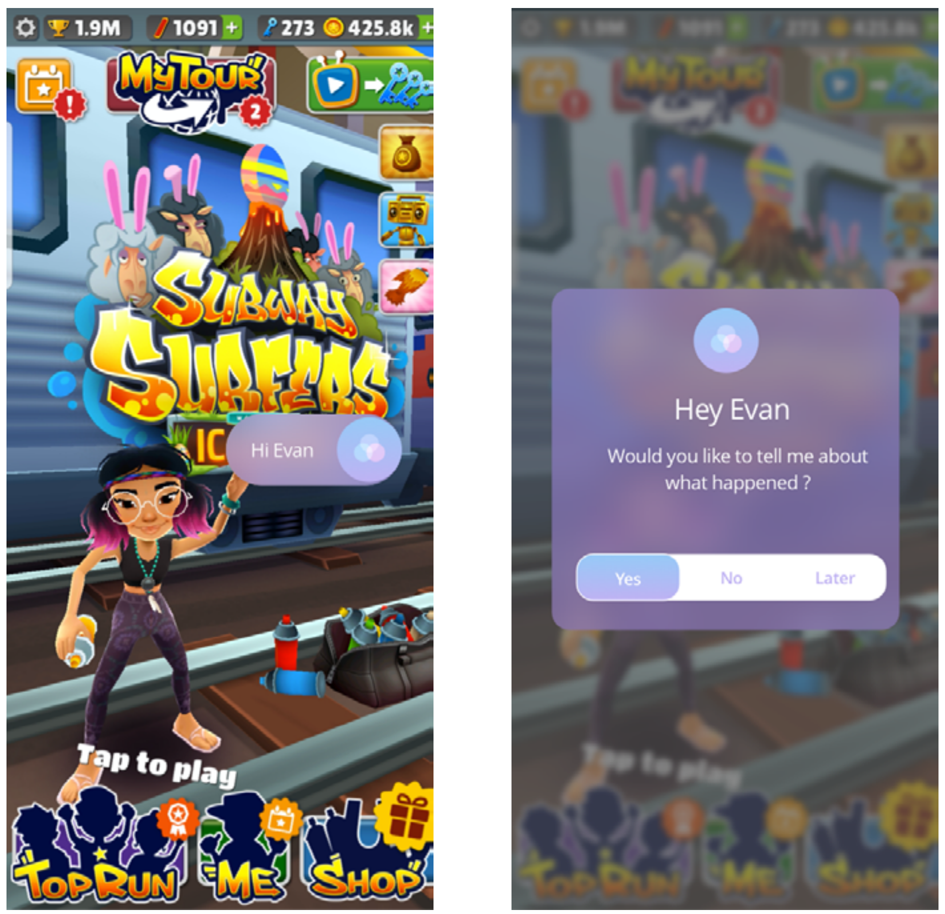

Figure 103 Checking in:
S.A.M. asks Evan if he wants to talk since, he is calmer.

Evan is ready to talk and begins to explain his situation.

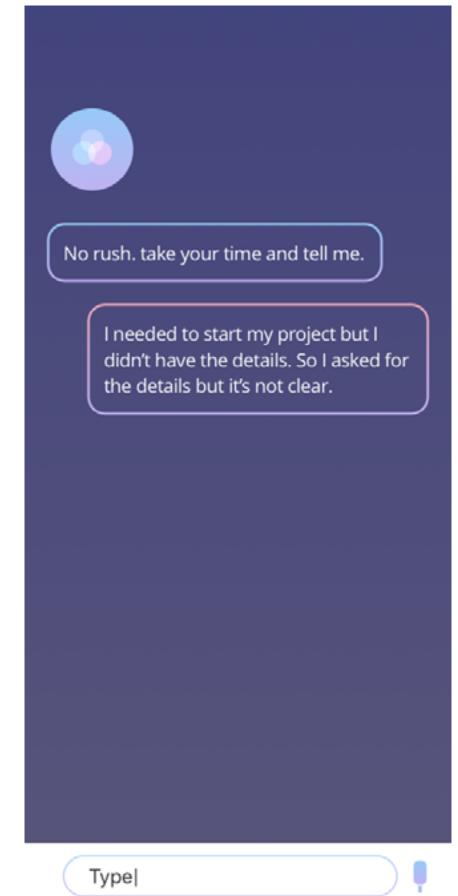

Figure 104 Explaining:
Evan explains his situation.

S.A.M. is not sure about a certain detail and asks Evan to clarify the information. S.A.M. highlights the sentence and asks him the question.

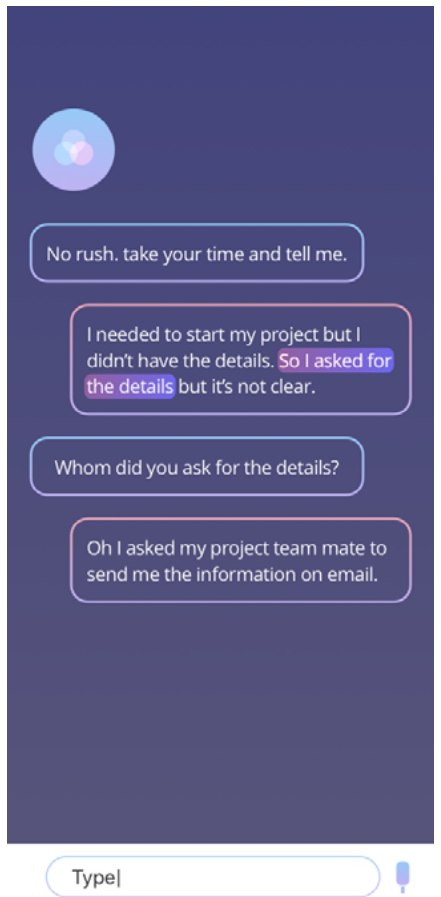

Figure 105 Text highlights:
S.A.M. highlights text that it needs more clarifying on.

S.A.M. evaluates the situation and decides the worry book intervention might be the best approach. S.A.M. tells Evan a story of someone in a comparable situation as he is. S.A.M. uses illustrations and is direct.

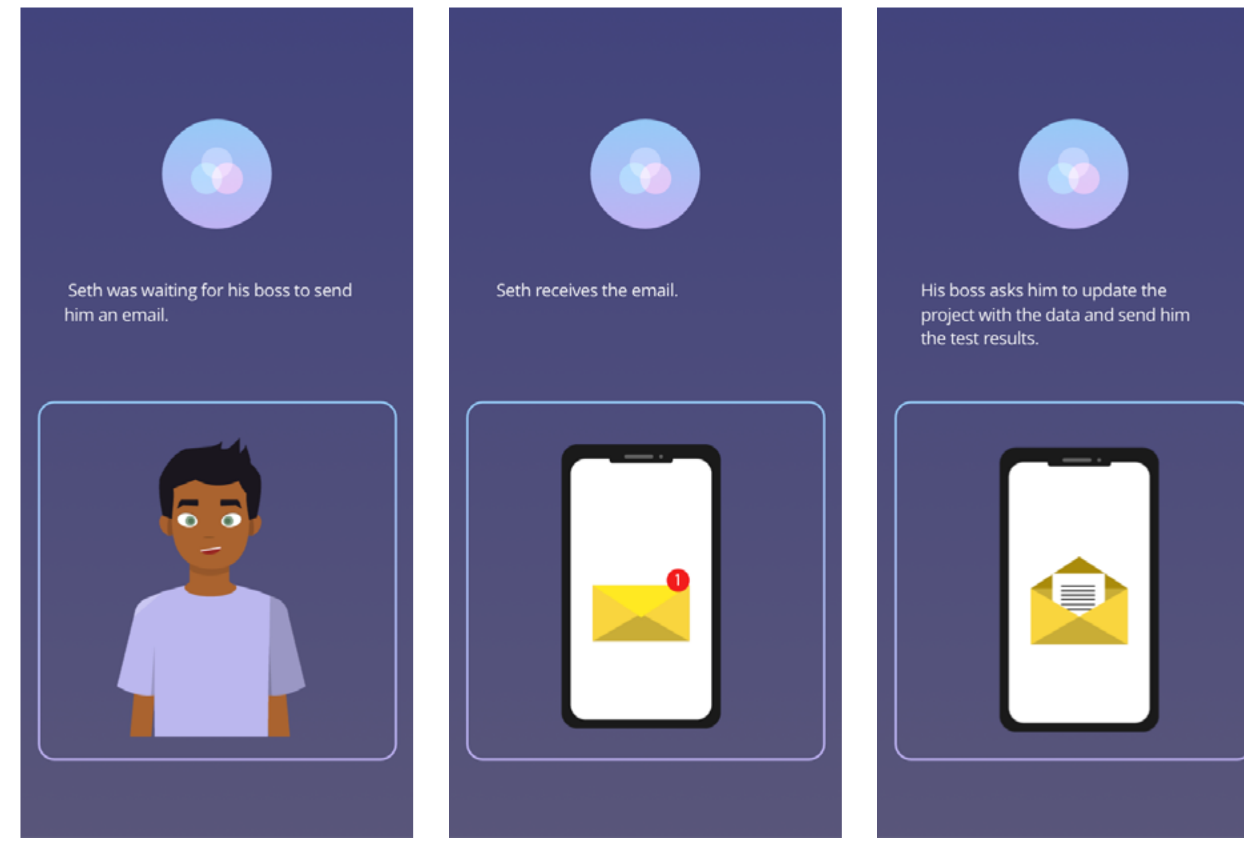

Figure 106 Worry book:
S.A.M. tells Evan a story of a person in a comparable situation as he is.

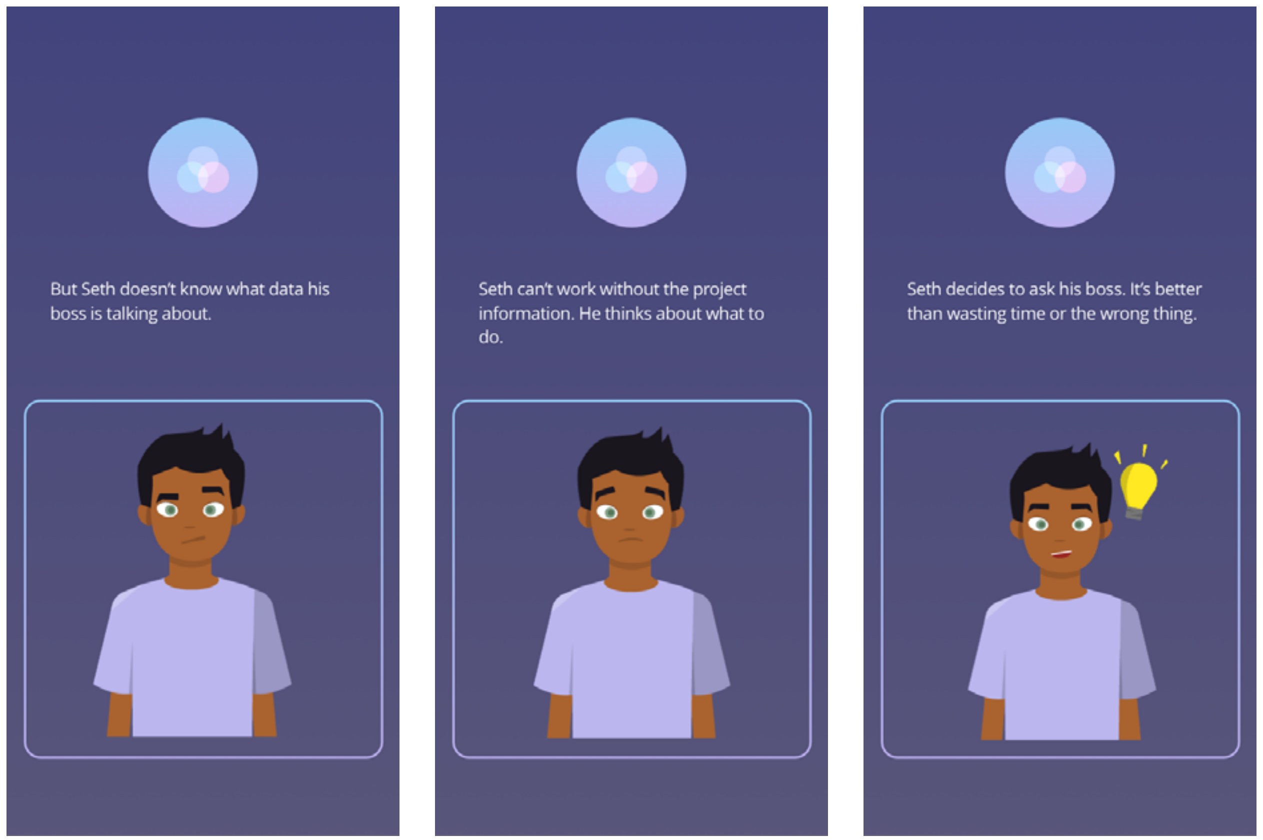

Figure 107 Worry book -1:
S.A.M. tells Evan a story of a person in a comparable situation as he is.

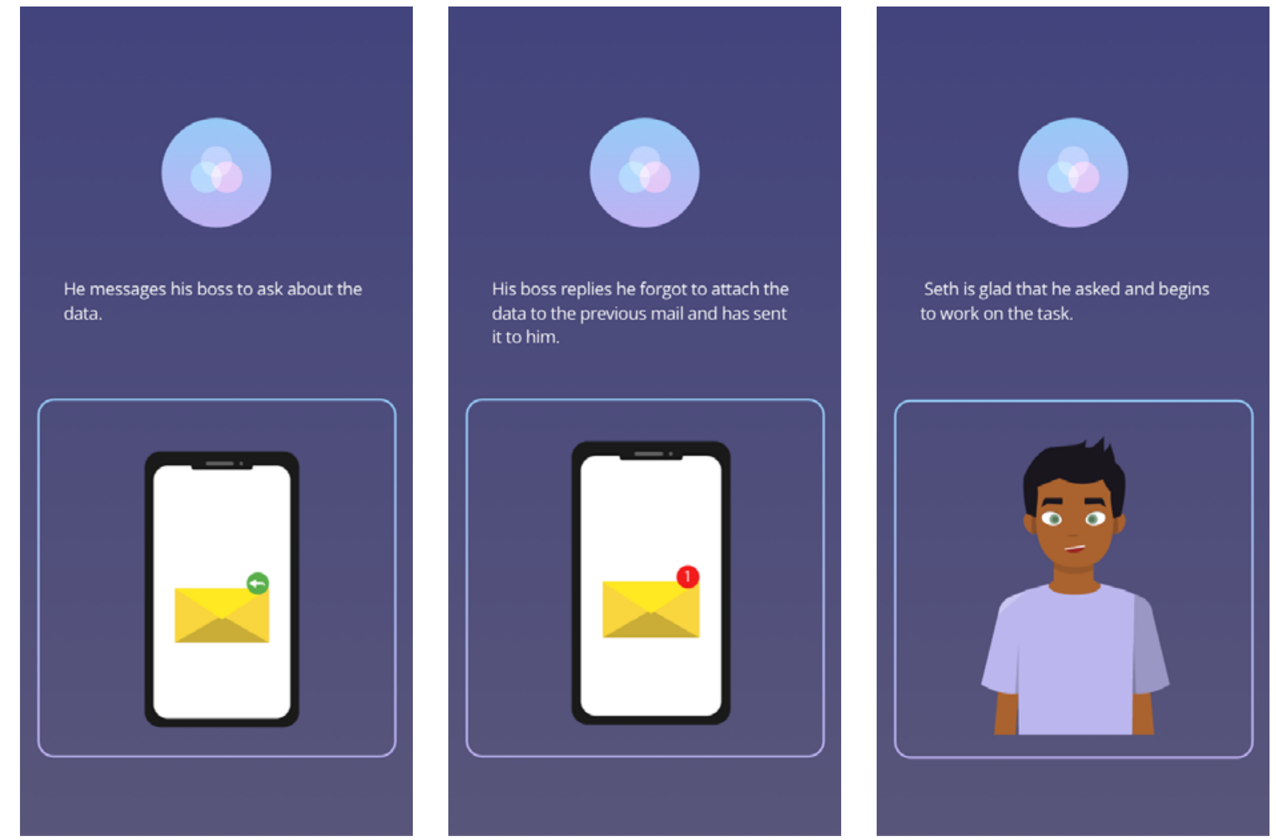

Figure 108 Worry book -2:
S.A.M. tells Evan a story of a person in a comparable situation as he is.

After the story, S.A.M. checks in with Evan if he understood the story.

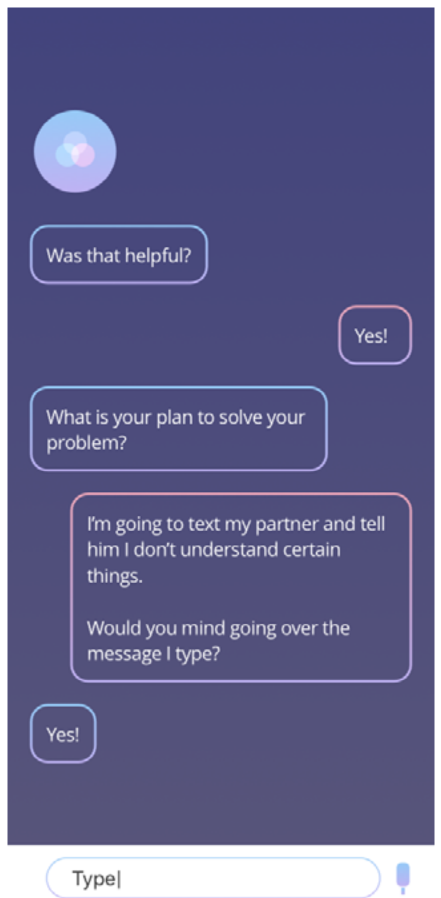

Figure 109 Checking in:
S.A.M. wants to check if Evan understood the story.

Evan asks S.A.M. to help him with forming the message. S.A.M. does so and explains the changes it recommends.

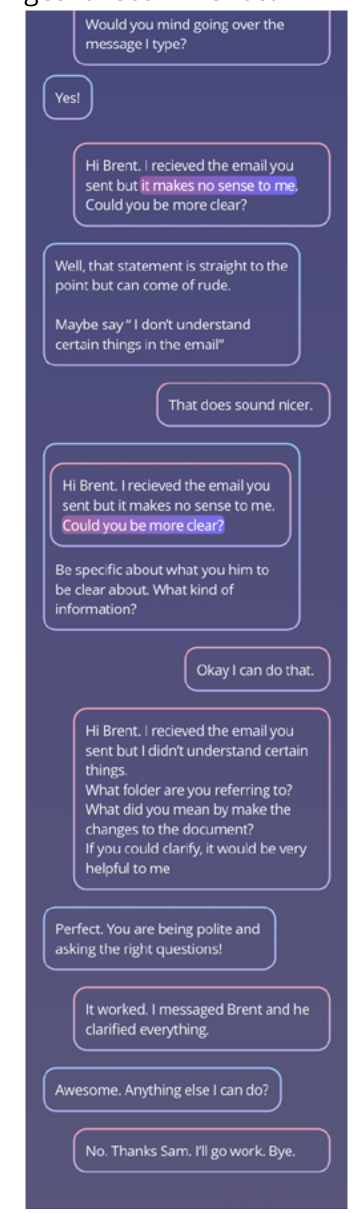

Figure 110 Text edits:
S.A.M. helps Evan in editing the message he sends to his teammate.

Overview:

Day 1	Day 60	Day 160
Evan does not respond well to breath-ing exercises. Prompts help Evan communicate more clearly.	Evan responds well to illustrations. Selective amount of op-tions works well with Evan.	S.A.M. has learnt Evan sometimes prefers talking about the problem later. Evan's messages can be too direct. Evan needs help in ex-panding his sentences and what he is trying to say. Stories are successful in making Evan understand.

Table 11 Comparison of Evan's experience over time:
Depicts the evolution of S.A.M. and Evan's relationship over the course of 160 days

DISCUSSION

Reflection

Through the course of this investigation, I was able to develop an intelligent system that took on the role of a mentor. With the support of the intelligent mentor, the student with autism can navigate stressful situations. The situations are stressful because the skills required to tackle the task does not come naturally to the individual. The person needs to exert more effort to resolve the issue. The intelligent system reduces the added effort by sharing the cognitive load and assisting the user in problem-solving.

In the pursuit to develop this mentor relationship between an intelligent system and the person, I made several discoveries supported by the studies which I believe can be of service to designers, engineers, and ML enthusiasts.

Establishing a Eelationship

Like human relationships, to form a mentor relationship between the ML system and the user, it takes time. The efficiency of the relationship depends on the amount of time put into its development. The relationship is bi-directional and built on trust. The more information the ML system has access to the more effective its responses will be. The ML needs to be mindful of the information it has been entrusted with and should be transparent about how it intends to use the information. Additionally, the design of the CUI should be able to reflect what it is doing so the user is aware, helping them trust the system. The more the two entities interact the more they learn about each other.`

Interventions During Stressful Moments

The moments of distress are sensitive and crucial. Intervening in such moments needs caution, empathy, and mindfulness. Bad implementation of the interaction can make the situation worse and increase the individual's distress. We need to design a means for the ML system to communicate and understand the user's preferences respectfully. When designing for such moments, the intervention needs to be designed in a way that the user has the option to decline or ask for an alternative. The various components of the interface need to be articulate and easy to understand. The visuals need to be easy on the eyes and seem approachable to the user. Unnecessary information or too many options can add more effort for the user. It is also important to note that the medium of conversation changes how the conversation takes place. The medium can be the device or the mode of communication e.g. spoken conversation. Depending on the medium, the language, amount of information, and structure will vary. Adding the user's personal preferences does make the design more complex but allows for a modular design system.

Collaborative Problem Solving

The word collaborative is key. The system is not solving the problem for the user. The system works with the user to solve the problem. Both the entities' skills are used to arrive at a solution. The ML system taps into its datasets to learn different approaches used for similar problems. The user processes that information and implements it to their scenario. The system should not assume the right way to support the user, rather it suggests a way or ways it could potentially help. The person is aware of their strengths and understands the kind of support they need to arrive at a solution. Patronizing the user or making the system present itself either visually or through language as superior would be counterintuitive. It would also be unfair and erroneous to assume the ML system is always correct. The goal of the mentor relationship is to empower the individual by combining the cognitive abilities of the individual with the ML system.

Moving Forward

Arriving at a possible solution is not enough. That does not solve the problem. Plus, the solution might not work for that scenario and will require a second round of problem solving. The ML system needs to work with the user to implement the solution. That will not only help the user learn to address similar problems in the future but will also help the ML system to learn the best course of action. The problem is not solved until actions are undertaken to resolve the problem. To resolve the problem the system needs to put forth the right questions to the user in an approachable and simple manner. The conversation and experience need to promote a sense of confidence and trigger a response. Negations and sarcastic replies must be avoided and in place use positive reinforcement to encourage the user to keep trying. The action needs to be put forth in a manner that looks achievable and easy to understand. Minimal and clean design is important.

I would like to emphasize that designing this experience is not based on just one factor. From creating conversations to interface components, multiple aspects of the system play a defining role in how the experience plays out. The system is a complex network and change in one area alters the outcome.

Conclusion

This investigation serves as evidence to the benefit of combining ML in designing interventions for autism. The intervention explored in this project is accessible and adaptable. These two qualities are important since autism is experienced differently by each individual, and the system will have to respond accordingly. The intervention does not disrupt the person's routine which is a common trigger for many people on the spectrum. Instead, the system integrates with smart devices that the individual is already comfortable with. The added advantage of doing so is that it reduces the learning curve associated with the intervention. People are more likely to use support, when needed, if it is easier to access interventions.

If I swapped situations between all my personas discussed in the studies, the system would respond and communicate differently. If either of the personas adds a new device, it would be interesting to see how the experience would play out. There is no way to predict the experience since it depends on the user-system interaction. Suppose Anya (refer to fig 78) used AlterEgo (refer to fig 34), the interaction could go many ways. Anya might be able to focus better with it so S.A.M. might shift a substantial part of their communication through AlterEgo. But the device could also further distract Anya which would make S.A.M. use the device as little as possible.

The explorations also pointed at the importance of having multiple ways to say the same thing - textual, image heavy, audio, audio-visual, haptic, audio-haptic, etc. In addition to this the amount of information that needs to be put before the user is critical. Combining the mode of communication and amount of information, the permutations of communication possibilities are huge. For this project, I used 3 different devices and with these 3 devices alone the amount of possibilities for communication is absurd.

Most importantly, the intervention respects the user's preferences. The system is going to avoid doing things the user does not like or things which serve as a trigger. This preference plays a key role in the conversations that take place between the user and the system. The AI's personality would also determine the nature of the conversation and the words it chooses. Hence, I designed my AI around mentors, and it reflects in the language. This choice would also affect the quality of the mentor relationship.

The solution is complex but promising. I hope this project is able to guide people curious about using ML to support autism. I believe this intervention creates an inclusive space for students on the spectrum and empowers them to compete on par with neurotypicals.

Future Scope

A huge part of autism research focuses on children. The reason for choosing the young population is logical but we cannot ignore the rest. Autism does not go away as you grow older. Earlier efforts have made it possible for students on the spectrum to enroll in universities and now it is time we focus our efforts in supporting them through graduation. The needs of adults on the spectrum differ from those of the children. This investigation highlights the importance of the problem space and potential of designed interventions. To move the research:

- Adoption of the study on a larger scale
- Further user research into gathering more insight into the user's problems.
- A multi-disciplinary design approach
- More research to augment the efficiency of the ML system discussed in the paper.
- A deeper study into designing interfaces for sensory interaction

There is so much untapped potential in this problem space and taking action would prove to be rewarding.

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