
Reflections on Designing an At-Home Wearable Aid with and for Families with Autism

Aaron Kline	akline@stanford.edu
Catalin Voss	catalin@cs.stanford.edu
Peter Washington	peterwashington@stanford.edu
Nick Haber	nhaber@stanford.edu
Azar Fazel	azarf@stanford.edu
Jena Daniels	danielsj@stanford.edu
Jessey Schwartz	jesseys@stanford.edu
Carl Feinstein	carlf@stanford.edu
Terry Winograd	winograd@cs.stanford.edu
Dennis Wall	dpwall@stanford.edu

Stanford University
Stanford, CA 94305, USA

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Abstract

In recent years, there has been increased focus on employing emerging technologies to make novel behavioral aids for those with autism. Many of these are direct digital translations of tools used in standard behavioral therapy, often used outside of the real world contexts in which the learned skills might apply. To address this, we have designed a system for automatic expression recognition on wearable devices that integrates directly into daily social interactions, giving families the tools and information they need to design their own holistic therapy. To develop a tool that will be maximally impactful to families, we have included children with autism and their caregivers in the process via an at-home extended iterative design study. By taking this approach, we aim to produce a framework for therapy that folds into daily life and serves specific needs in a way that only involving families themselves in the design process can provide.

Author Keywords

Autism; Behavioral Therapy; Wearable Computing; Ubiquitous Computing

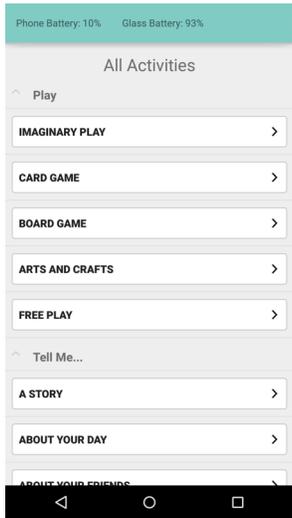


Figure 1: The system offers families various activities to try, as well as a way to review their sessions of emotional interaction. While reviewing the videos, users can reflect on specific behavior and highlight sections of particular interest or write comments.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

Introduction

Autism is quickly becoming a global health crisis, with 1 in 68 children affected by Autism Spectrum Disorder (ASD) today [1,2]. Many of these children experience challenges with social skills ranging from difficulty with recognizing facial expressions and making eye contact to struggles with interpreting interpersonal interactions [3]. Today's best-known intervention, applied behavioral analysis (ABA), relies on teaching these skills in clinical sessions, via tools such as flashcards [4]. While this approach has had some therapeutic success [1], they are typically deployed in structured clinical environments, removed from the contexts in which the social skills taught must actually be used.

To address this, we have developed an at-home learning aid using automatic facial expression recognition that runs on wearable glasses and delivers real time social cues to individuals with ASD in their natural environment. The system offers various gamified activities that allow families to shape informal behavioral therapy sessions, and a detailed behavioral review that enables users to revisit those sessions along with the real-time feedback they received (Figure 1). Together these interaction tools aim to unlock the child's social awareness and ability to build more informed responses to the social situations they encounter. The details of our system are described in [5]. By taking a multi-phased approach to development, first designing the system iteratively with a small group of participants then scaling to a larger group for clinical validation, we believe that we can

create a program that will be impactful to children with autism across the spectrum.



Figure 2: Various visual feedback cues were considered while developing the system.

Iterative Design Study Findings

To design a system that could better integrate into and enrich the lives of those with autism, we embarked upon a 3-month iterative design process with 14 families affected by ASD. Participants ranged across the spectrum, with Social Responsiveness Scale (SRS) scores varying from mild to severe, Abbreviated Battery IQ (ABIQ) scores ranging from 47 to 127, and with various sensory and attentive challenges. Families were asked to explore every aspect of the system over an extended period of time at home, and to return for biweekly check-ins in the lab for design discussion and iterative software updates.

Contributions from participants across the spectrum proved vital to the design process. Overwhelmingly the children preferred to receive feedback that offered the highest amount of sensory stimulus within the system we provided; that is, children preferred receiving both visual and audio feedback of emotions, and the most prominent indicator we offered signifying when they were engaged with a face. This contradicted initial concerns that sensory overload may be problematic.

However, some participants did have challenges, in particular with receiving audio feedback. This led to the decision to provide all available feedback by default, with a "mute" option for withholding the audio cues. A more recent study participant with audio sensitivities initially used the device at home with the mute button on; however, within a few weeks they had instead chosen to unmute it and then preferred to use it with audio enabled. This confirmed the design decisions to provide all feedback by default, but with a "mute" option available.



Figure 3: Families were asked to choose between different indicators of facial engagement, as well as whether to receive video and audio feedback of emotions.

The at-home longitudinal aspect of the study also proved key for participant contributions. All participants remarked that the headset became warm over time; however, at-home use over an extended period proved that this aspect did not have a significant dampening effect on participants' willingness to use it. Meanwhile, having the children point out where the headset became warm then informed the design of a heatshield (Figure 5) that more recent participants have found helpful.

Strengths found to be common in many children with ASD also proved valuable to the design process. The tendency to focus on details of design/work observed by Benton, et. al [8] was evident in our study

participants. One child was motivated to choose his own emoji for each emotion recognized by our system (Figure 4). Team members did not understand the child's custom emoji for sadness; when asked, the child described that he had not chosen the image to represent sadness, but rather as an image that would make himself laugh when he felt sad. This reflects Spiel et al.'s commentary regarding the importance of respecting children's design choices when team members might not understand them [9]. The child's emoji choices also highlighted an emotion that he had difficulty understanding (contempt, or "meh") in a way that may not have been noticed otherwise. This process of personalizing emojis resulted in aspects of the child's engagement with emotions in a way that verbal discourse may not have captured.



Figure 4: Custom emojis selected by a study participant, demonstrating different approaches and levels of engagement for different emotions.

Increased focus and knowledge regarding hobbies and interests [6, 8] also played an important role. A recent brainstorming session with some participants of the study included contributions based on a shared love of



Figure 3: Headset with heatshield design informed by study participants. The “SuperpowerGlass” name was adopted from a child’s description that the system’s prediction of emotions made them feel as if they had superpowers.

video games, with requests related to popular games such as Candy Crush, Roblox and Minecraft, as well as the creation of personalized avatars. One study participant with an interest in engineering had specific suggestions for how Google could better design their next version of Glass. While the team could not implement those suggestions due to safety concerns, they did give insight into what aspects of the system were and weren't working for them in a way that may have been more difficult for them to express otherwise.

Design Process Challenges

Behavioral aspects common in children with ASD also resulted in challenges for the design process. Distractibility and limited tolerance for the duration of the biweekly check-ins occurred frequently. A number of children found providing feedback stressful or difficult enough that their design preferences and contributions needed to be expressed through parents or siblings as design proxies.

The format of the study itself also posed challenges for the design process. While the at-home extended use nature of the study was crucial for producing feedback based on extended use in a setting in which the children were very comfortable (at home with family members and friends), it also meant that holding the biweekly check-ins for all 14 participants in their homes was not logistically feasible. As a result, all in-person collaboration opportunities between the lab team and families occurred by necessity in-lab, as opposed to in a setting in which they may have been more comfortable - an aspect identified as an important factor for preparing an environment conducive to design with those with autism [8]. It remains both an ongoing challenge and opportunity to synthesize the insights

gathered in the in-lab check-in context with the video and feedback gathered from extended use in the home.

Future Work and Conclusion

As part of developing a therapeutic learning aid for those with autism, we have conducted an extended at-home iterative design study with families affected by ASD, gathering vital first-person input into how such a system could best be designed to integrate into families’ lives. Currently we are using the design lessons learned from that process to conduct a 50-person randomized controlled trial, and in parallel are beginning another phase of iterative design with many of the same families involved in the previous study. Synthesizing the multimodal data from the previous study, ranging from video data and both qualitative and quantitative feedback from extended use in the home to the design feedback gathered during in-lab check-ins will be vital to inform the next design iteration. Challenges remain for how to best capture children's contributions both in-home without team members present, and with team members present but in a less comfortable lab setting; and for how to best honor the experiences of children with challenges so advanced that their contributions must be communicated through design proxies such as parents and siblings. We look forward to applying the substantial insights of the participatory design community regarding how to best synthesize this multimodal data and better capture children's contributions for our next design phase.

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