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# Perspectives on Designing a Wearable Learning Aid with and for Families with Autism

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## Abstract

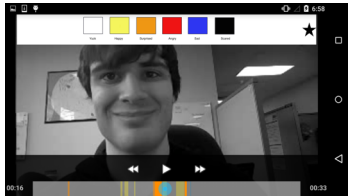
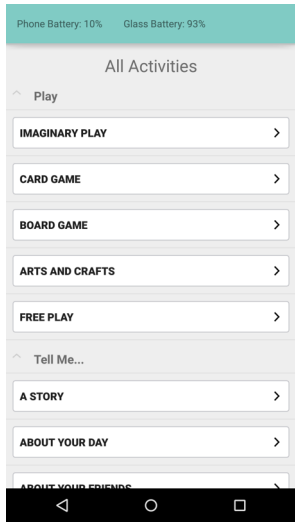
Recent developments in wearable devices provide a strong opportunity for researchers and designers to create assistive technologies for those with autism spectrum disorder (ASD). We have developed a therapeutic learning aid, using automatic expression recognition on Google Glass, that integrates directly into families' daily social interactions. With the goal of providing a platform for families to directly shape therapy to best fit their own needs, we have included families of individuals with autism in every phase of the development process, including a recent at-home extended iterative design study. Having completed this phase, we reflect on how our intentions for the system have been shaped by the design trial, how successful the process has been so far, and how we might be able to expand the successes we have seen to others beyond our design collaborators.

## Author Keywords

Autism; Behavioral Therapy; Wearable Computing; Ubiquitous Computing

## ACM Classification Keywords

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



**Figure 1:** The system offers families various activities to try, as well as a way to review pre-curated videos of their sessions of emotional interaction. Users can reflect on specific behavior and mark particular parts of the session as important or write comments.

## Introduction

Recent reports reveal that as many as 1 in 68 children are on the autism spectrum [1,2]. Children with autism typically experience impairments in the acquisition of social skills, such as difficulty with recognizing facial expressions and making eye contact [3]. Today’s best-known intervention, Applied Behavior Analysis (ABA), relies on teaching these skills in clinical sessions with tools like flashcards [4]. While this approach has some documented therapeutic success [1], ABA typically occurs in structured clinical environments, removed from the contexts in which the social skills taught must actually be used, such as the child’s home.

To address this, we have developed an at-home learning aid on Google Glass using automatic facial expression recognition to deliver real-time social cues to children with ASD. The system includes various gamified activities that children can use during informal behavioral therapy sessions. By providing a detailed behavioral review that highlights emotional moments in a video (Figure 1), we enable families to re-examine their social interactions throughout the day. The system has been named “Superpower Glass” by some participants and its details are described in [5].

As part of a multi-stage development process, we have conducted an in-lab study with 43 children (including 23 with autism) and completed a 3-month iterative design process with 14 families of individuals with autism. The lessons learned from these studies have informed a larger 50-family randomized controlled trial, currently underway, to further confirm clinical validity. In parallel, we embark on another iterative design study, with many of the same families who previously contributed to the design process. Building upon the

discussion at the CHI’16 workshop on “Autism and Technology Beyond Assistance & Interventions” [8], we now consider how our intentions for the system have been refined by the most recent design trial, how we assess the successes and challenges it has raised, and how we might be able to expand the successes we have seen to others in the future.

## Are We Trying to Do the Right Thing?

Our intention for the Superpower Glass system is to place the ability to shape holistic therapy for families of individuals with autism into the hands of the families themselves. Therefore, it was clear that we must include families directly in the design process and must do so in the most open way possible, giving children with autism and their caregivers the most freedom to inform how to best design the tool. As a result, when we began to develop activities around our emotion recognition software, we provided a few structured options to try (ranging from simply giving emotional cues to more complex games, prompting children to provoke emotions), but also an unstructured option to use as they saw fit. As an idea from a parent brainstorming session, we also included a *behavioral review* system for revisiting those sessions, but again left it in the hands of the families to choose how to have those reviewing conversations. We then asked families to try all different aspects of the system, for a minimum amount of time over the span of a number of weeks, but otherwise left how they felt that was best accomplished in their hands.

This approach accomplished the goal of leading with family input first, and confirmed that what we’re pursuing in general is seen as very valuable by the participants. However, the openness of this approach

has also proved challenging. The vast majority of families remarked that when using the unstructured activity, they were unsure about what to do, and could use further prompting or scoping. The addition of some ideas for framing the activity (Figure 1) was found helpful for some families. Meanwhile, enthusiasm among parents for the use of the behavioral review functionality and its potential for fostering bonding and reinforcing conversations was high. However, in majority the behavioral review proved to be underutilized, with the general consensus being that without more framing around how to use the review and to what end, families were unsure what to do with it. In general, it appears that striking an appropriate balance between freedom and structure, shown to be key for individuals with autism [7], also applies to our design families as a whole.

Additionally, while it is ideal to have children with autism be full design partners [6], a number of our design participants found providing feedback stressful or difficult enough that their design preferences and contributions needed to be expressed through parents or siblings. It remains an ongoing challenge in our design process for how to best honor the experiences of children with challenges so advanced that their contributions must be communicated through design proxies. In general, we believe that direct iterative design with families of individuals with autism is still the key to developing a therapeutic platform that best serves their needs. That being said, challenges regarding the best level of structure to foster design input, and how to best reflect the design intentions of children who find communicating those intentions directly challenging must continue to be addressed as we proceed with the next design iteration phase.

## **Is it Working?**

The results of the iterative design study have been very promising. We have received qualitative feedback from both children and parents that the system has been helpful for increasing social awareness and eye contact.

*"It's helped me to understand some people's emotions...I can tell when a friend is upset better now than I could before." "I've been applying what I saw with the Google Glass to situations without the Google Glass...I would see my friend's face and it would look similar to one of the faces I saw on my parents when they were upset so then I could ask my friend, 'What happened?'" - Participant 3 (15 years old, female)*

In a number of cases, we have received similar feedback describing that third parties such as teachers who were not aware of the study also noticed improvements.

*"We already noticed something very dramatically I like to share. [Participant 1] is actually looking at us when he talks through Google Glass during a conversation and it was noticed without glasses from his teacher in Language Art yesterday, its [sic] almost like a switch was turned. We found this very important to share and I hope it will help your research to take a closer look at this event when other kids will start wearing the glasses. Thank you!!! My son is looking into my face." - Participant 1's Parent*

These results have been echoed by changes seen on the parent-administered Social Responsiveness Scale



**Figure 2:** 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.

(SRS) over the course of the study, with an average improvement of 7 points, and 6 children changing autism ranges from severe to moderate or moderate to mild.

Throughout the study, the design participants maintained a high level of enthusiasm. 12 of the 14 families who completed the iterative design study have remarked that they would like to be involved in the next phase of the project, and engagement with a number of those families is already underway; one of the children remarked that they were “sad” to have to return the system, and will be re-joining the next design phase as well.

Despite the encouraging feedback, the design study highlighted several particular challenges on which to focus for this next development phase. With extended use at home, a number of participants became less engaged, feeling that they had accomplished everything the system had to offer, and looking for additional challenges or gamified opportunities. Also, both interaction sessions and session review were framed to be managed completely by caregivers; this could, unintentionally, skew interaction feedback and design input to overemphasize caregiver contributions over those of the children. It is important to consider whether transferring more control over the interactions and review to the children could provide a different balance of results, as well as have an effect on their engagement over time. Finally, while the in-depth involvement of caregivers in the design process has been crucial, that involvement could also potentially influence their administration of the outcome measures for the study. We have addressed this in our randomized trial by tracking child outcomes more

directly through semi-structured interviews like the Brief Observation of Social Communication Change (BOSCC), as well as via teacher-administered measures. As we continue our iterative design trials, we believe that it is vital to track child successes independently from caregivers, particularly when these caregivers are key participants in the design process.

### **Does it Matter?**

While the results of the iterative design study were very promising, it is important to consider how that potential success could be expanded to children beyond the group enrolled in our design trial, given the heterogeneity of ASD. We are currently conducting a larger, 50 person randomized controlled trial to explore exactly this – offering the system to more families in a more structured way to pursue additional clinical validity of the lessons we learned through the design study.

We believe that the combination of two specific factors of our design study provide a powerful base from which we can increase the likelihood that the success we have seen will translate to others:

- 1) a diversity of design contributors across the spectrum of autism,
- 2) and an at-home longitudinal approach to our design study.

Together these have allowed us to shape our design decisions in a way that are more likely to translate to others beyond our design collaborators. Having collaborators with different reading and visual perception skills allowed us to iterate on visual feedback to reach a representation we feel is accessible

to the most children going forward (Figure 3). Having children with different sensory sensitivities use the system at home over an extended period of time allowed us to conclude that we can offer visual and audio feedback of all kinds by default, and include a mute button for those with audio sensitivity. That variety of sensitivities has also allowed us to conclude that children are willing to wear the headset even when it becomes warm, and has helped us design a heatshield that improves the likelihood that others beyond our design collaborators will also wear it over extended use (Figure 2). Overall, we believe that having design partners with diverse skills and challenges across the spectrum, and allowing them to explore design possibilities in the comfort of their homes over an extended period of time can greatly increase the likelihood that design decisions may generalize well to others beyond those directly involved in the design process.



**Figure 3:** Various visual feedback was considered in order to discover the most accessible approach for children with different reading and visual perception skills.

However, while our participants reflected a diversity of interaction capabilities and challenges, they were limited geographically to the area near Stanford University. Expanding development phases to be capable of including remote participants, while extremely challenging in a number of ways, will be very valuable to increasing the diversity of design contributions, and expanding success of the system we

are developing. We are now beginning this process by enlisting the first group of remote study participants in the design arm of our trials.

## 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 regarding how such a system could best be designed to integrate into families' lives. That process has helped us further shape our intentions for what the system should provide, given us ways of measuring success for what the platform can accomplish, and has highlighted some factors of the design and development process with those with autism we feel are key for increasing the likelihood of expanding that success to others in the future. We concluded that our overarching philosophy of including families directly in all stages of the development process, including via at-home extended iterative design studies, and doing so in the most open, family-first way has been the most successful aspect of our work, and remains key to creating a system that best integrates into their daily lives. Through this approach, we have learned important lessons regarding the challenges of providing freedom-structure balance and how to best honor the contributions of the children in particular in that process. Currently we are applying these learnings in a more structured 50-person randomized controlled trial, and look forward to having those insights inform another iterative design phase with many of the same families returning to contribute to the process again.

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## References

1. Dawson, G. and Burner, K., 2011. Behavioral interventions in children and adolescents with autism spectrum disorder: a review of recent findings. *Current opinion in pediatrics*, 23(6), pp.616-620.
2. Developmental, D.M.N.S.Y. and 2010 Principal Investigators, 2014. Prevalence of autism spectrum disorder among children aged 8 years-autism and developmental disabilities monitoring network, 11 sites, United States, 2010. *Morbidity and mortality weekly report. Surveillance summaries* (Washington, DC: 2002), 63(2), p.1.
3. Hobson, R.P., 1995. *Autism and the development of mind*. Psychology Press.
4. Rebecca J. Landa, Katherine C. Holman, Allison H. O'Neill, and Elizabeth A. Stuart. 2011. Intervention targeting development of socially synchronous engagement in toddlers with autism spectrum disorder: a randomized controlled trial. *Journal of Child Psychology and Psychiatry* 52,1: 13-21.
5. Catalin Voss, Peter Washington, Nick Haber, Aaron Kline, Jena Daniels, Azar Fazel, Titas De, Beth McCarthy, Carl Feinstein, Terry Winograd, and Dennis Wall. 2016. Superpower glass: delivering unobtrusive real-time social cues in wearable systems. In *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct (UbiComp '16)*, 1218-1226.
6. Benton, L., Johnson, H., Ashwin, E. and Grawemeyer, B. (2012) *Developing IDEAS: Supporting Children with Autism within a Participatory Design Team*. *Proceedings of the 2012 annual conference on Human factors in computing systems* (pp. 2599-2608). Austin, US: ACM Press.
7. Katharina Spiel, Laura Malinverni, Judith Good, and Christopher Frauenberger. *Participatory Evaluation with Autistic Children*. 2017. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*, 5755-5766.
8. Christopher Frauenberger, Judith Good, and Narcis Pares. 2016a. *Autism and Technology: Beyond Assistance & Intervention*. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '16)*. ACM, New York, NY, USA, 3373-3378.