Augmentative Alternative Communication for Non-Verbal Autism with Grip Sensors

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ABSTRACT
Children with Low-Functioning Autism suffer from severe communication deficits and emotional control. A wide range of popular technologies for these children emphasize complicated interactions, while ignoring the potential impact of emotional cognition on linguistic development. To improve both intrapersonal and interpersonal communication skills, we detail the design and evaluation of a simplified augmented alternative communication system utilizing stress ball grip sensors. Semi-structured interviews with speech-language pathologist subject matter experts and autism researchers are used for initial design evaluation in preparation for more extensive usability testing with target-user children and parents/guardians.

Author Keywords
[Subcommittee: Specific Application Areas]

[Affective computing; autism; embodiment; etc.]

ACM Classification Keywords
H.5.2.g. **User Interfaces:** **Haptic I/O**

INTRODUCTION

Autism is a spectrum of neurodevelopmental disorders characterized by limited social skills. It is estimated that 1 of 88 children age 8 have some form of Autism Spectrum Disorder (ASD) [1]. While symptoms can vary widely between individuals, autism symptoms begin to manifest in very early childhood and can be an emotional challenge for parents, causing extreme difficulties not only in the development of communication but also memory impairment, epilepsy, impaired emotional control, and, relatedly, self-harm [2, 3]. In one case, 61% of ASD children completely failed to develop speech [4].

Luckily, there is some evidence to support the belief that early intervention, while unlikely to change the fundamental elements of autism itself, may ameliorate symptoms and improve communication skills, increasing overall quality of life [5, 6].

To aid in day-to-day life and to develop necessary skills, some are given aided augmentative and alternative communication technologies (AAC). The relative popularity of these technologies has led to a proliferation of competing software. At the time of this publication, the authors observed over 250 AAC offerings within the Apple iTunes App Store©, alone, with a cost range of free to $250. While these technologies have met with substantial acceptance from worried families, there appears to be a dearth of evidence to specify the overall effectiveness of these technologies [7]. Additionally, there has been some concern that research overwhelmingly focuses on high-functioning autism (HFA) cases while increasingly ignoring low functioning autism (LFA) cases [8]. This is problematic, as resources are directed away from the most severe cases to focus on normalization of the most easily benefitted, leaving the neediest children with the least support.

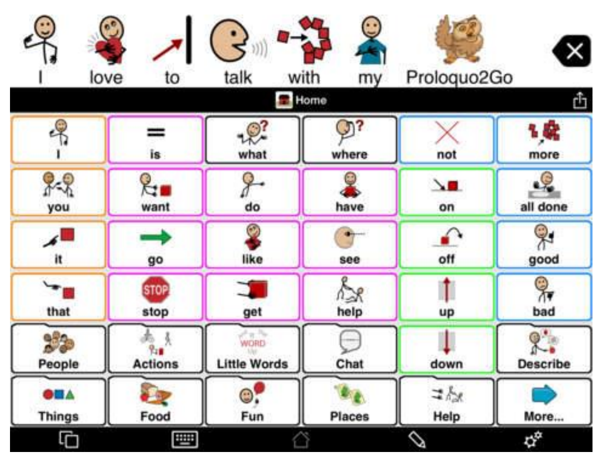

Figure 1: Proloquo2Go for iPhone Screenshot

Figure 2: Alexicom Elements for iPad Screenshot

Ideally, AAC should have two goals, to support immediate communicative competence, and develop skills for communication in the future [7].

As ASD children are frequently more apprehensive of, and slower to adapt to, new situations, the relative complexity of existing AAC solutions may be problematic. Limited emotional control is a major consideration; frustration provides a possibility of interventions backfiring. As such, engagement is of high concern for involved interfaces and there may be a great advantage in focus on interface simplicity and playfulness instead of simply expanding on features[9].

To better address these limitations, we need to address how these children are modeled as users. While there is a temptation to suggest that these children simply need access to an applicable pictorial dictionary, this perspective does not consider the massive amount of development that occurs during childhood, ignoring the embodiment at work in childhood experience. The Schachter-Singer two-factor model of emotional experience suggests that emotional cognition is the result of both cognitive labels and identification of physiological response [10]. In the case of children who are developing cognitive labels, it can be frustrating to deal with emotional experiences they cannot express. By providing an extensive collection of existing labels, like some AAC systems, designers are making the assumption that the primary cause behind a child's difficulty with verbal communication is due to their inability to use their mouth to form the correct word. This is comparable to modeling the child as someone with fully developed speech and understanding and limited communication channels, rather than someone with little understanding of what their own experience *is*. This suggests that the lack of emotional control demonstrated by many ASD children is the result of an inability to understand or describe the emotions they are experiencing.

Likewise, several previous studies have shown the effectiveness of such an approach. Sitdhisanguan et al demonstrated that tangible user interfaces (TUI) and touch-based systems provided superior ease-of-use and skill improvement with LFA children, whose motor skills may also be limited [8]. Koo's TellMe system provided a series of wearable sensors and interactive elements to reduce the anxiety levels of ASD boys and improve emotional communication. Different robot characters represented different emotional reactions and opinions, such as Nobot, which represented negative sentiments and disapproval, and Joybot, which represented positive affect and approval [11].

METHODS

We designed a prototype TUI AAC for improving emotional communication skills utilizing a simple resistive analog grip sensor housed inside a foam stress ball connected to a LilyPad© Arduino system. Feedback was provided by a series of LEDs that increased in magnitude in a linear scale correspondence with grip strength.

At the time of submission, evaluation has only been performed as initial, unstructured interviews with students performing related research. As such, we detail a two-stage evaluation protocol suitable for our design's focus on a special population.

Prototype Design

Our initial design concept involved the use of an analog grip sensor. As no commercial options were readily viable, we adapted the format utilized by Kirk [13], which consists of a layer of Velostat resistive fabric sandwiched between two layers of conductive fabric (Figure 3).

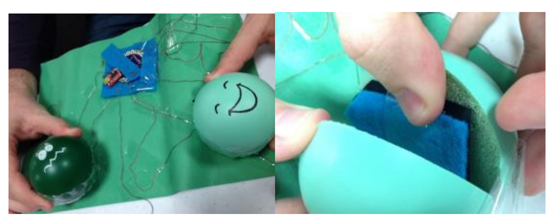

Figure 3: Prototype Sensor Design

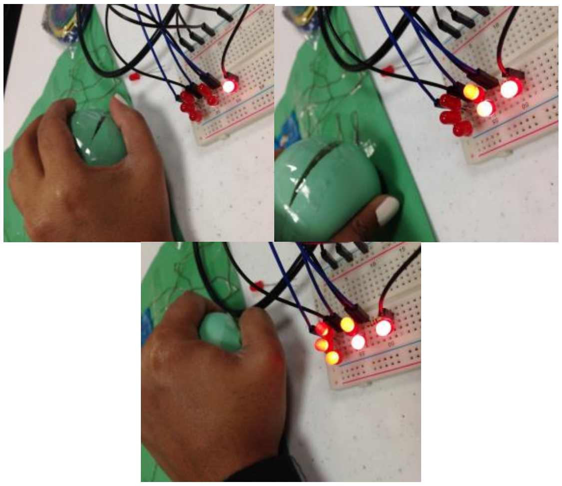

Figure 4: Light Magnitude Series

Feedback was provided as an increase number of LED lights, patterned after a filling triangular meter (Figure 4). This was chosen so as to provide a redundant display with magnitude shown by both height and number of lights.

Magnitude was considered as a major design factor to account for need for children to learn the differences between the same concepts at different levels of emphasis, a key component in speaking and understanding language.

Initial User Feedback

The initial breadboard prototype was subjected to feedback through unstructured interviews during an open demonstration for the Texas A&M Embodied Interaction Laboratory. Participants were students in the Visualization Studies Embodied Cognition class who had been working on similar projects throughout the semester.

Feedback suggested several guidelines for improvement. First, as the design is intended for implementation in a soft toy for children, participants questioned whether or not children would experience mode-confusion between communication and unstructured play.

Other participants voiced challenges for the eventual soft-design in how the stress balls would be physically placed in to provide accessibility and how they would be coordinated with the placement of feedback lights.

Additionally, participants indicated a strong positive visceral affect upon tangible manipulation of the stress balls. We reasonably expect this sentiment to carry over to our target test-base

Subject Matter Expert Interviews

After incorporating the design considerations gained from early feedback, the next stage of evaluation will consist of semi-structured interviews with subject matter experts in speech-language pathology. As these SME's are considered experts in the practical application of AAC technologies, they are expected to be able to provide effective design feedback and advice over the design of the final-stage target-user usability study.

The first component of the interview will consist of an initial background interview, covering subjects such as the range of experience dealing with non-verbal autistic children, the range of interventions they've had experience with in the past, the most effective interventions, and common pitfalls of existing approaches.

The second interview component will be a device evaluation by the SME's. After initial impressions and recommendations are recorded, SME's will complete a short survey over usability components of the system on a 5-point Likert scale to provide measurable feedback over device decisions.

Target-User Usability Study

The second phase study will focus on the comparison between three treatments: our design, non-augmented communication, and existing AAC software (potentially one recommended for comparison during previous interviews). Users will consist of parent-guardian/child pairs cooperating in a communication task, for example, a mock scenario deciding what to eat for dinner.

Observational evaluation criteria will consist of the number of discontinuities in interaction, the number of expressed frustration events, and the total time to accomplish each phase of the task. Afterwards, the parent-guardian will complete a feedback survey structure on a 5-point Likert-scale, structured around questions such as: "This system makes it easier to communicate with my child" and "I feel that I understand what my child is trying to express". Exit interviews and open response feedback sections on the survey form will be used.

Additionally, due to the potential exhaustion of our child subjects and the multiple treatment conditions, it may be necessary to operate the study as a between-subjects comparison to prevent causing undue stress .

RESULTS

The initial design provides several physical product design challenges, as can be seen in initial feedback, that we are currently unsure how to address. Further research and prototyping will be explored to finalize a more specified end design format.

Future development, beyond the evaluation steps described previously, will focus on providing adjustment methods to account for personal differences in grip strength, implementation of an improved output display, and investigation into the use of FlexForce© sensors to replace the current Velostat configuration.

CONCLUSION

While AAC has proved to be a popular ASD intervention method with families and some professionals, current approaches may suffer from several pitfalls, such as over-complex interaction, poor validation of effectiveness, and focus on only one aspect of the user population.

To address these concerns we designed a simple TUI AAC system that provided yes/no responses with magnitude mapped to the strength of the child's grip. While our system is simple, it is our prediction that it will prove to better develop emotional control and encourage progress in verbal communication as it is more compatible with accepted theories from the perspective of emotional and embodied cognition.

Design evaluation is currently incomplete, but will make use of speech-language pathologist SME's to tailor design decisions in preparation for a more detailed usability study of parent-child dyads comparing competing status quo AAC options, non-augmented communication, and our design.

ACKNOWLEDGMENTS

Materials, in part, and instructional oversight for this research were provided by the Texas A&M Embodied Interaction Lab.

REFERENCES

[1] Baio, J. Prevalence of Autism Spectrum Disorders: Autism and Developmental Disabilities Monitoring Network, 14 Sites, United States, 2008. Morbidity and Mortality Weekly Report. Surveillance Summaries. Volume 61, Number 3. *Centers for Disease Control and Prevention,* 2012).

[2] Volkmar, F. R., Lord, C., Bailey, A., Schultz, R. T. and Klin, A. Autism and pervasive developmental disorders. *Journal of child psychology and psychiatry*, 45, 1 2004), 135-170.

[3] Whitman, T. L. *The development of autism: A self-regulatory perspective*. Jessica Kingsley Publishers, 2004.

[4] Weitz, C., Dexter, M., Moore, J., Glennon, S. and DeCoste, D. AAC and children with developmental disabilities. *Handbook of augmentative and alternative communication*1997), 395-431.

[5] Eaves, L. and Ho, H. The Very Early Identification of Autism: Outcome to Age 41/2–5. *J Autism Dev Disord*, 34, 4 (2004/08/01 2004), 367-378.

[6] Goldstein, S. and Naglieri, J. A. AUTISM SPECTRUM RATING SCALES (ASRS™). *Tonawanda, NY: Multi-Health Systems*2009).

[7] Mirenda, P. Autism, Augmentative Communication, and Assistive Technology What Do We Really Know? *Focus on Autism and Other Developmental Disabilities*, 16, 3 2001), 141-151.

[8] Sitdhisanguan, K., Chotikakamthorn, N., Dechaboon, A. and Out, P. Using tangible user interfaces in computer-based training systems for low-functioning autistic children. *Personal Ubiquitous Comput.*, 16, 2 2012), 143-155.

[9] Keay-Bright, W. and Howarth, I. Is simplicity the key to engagement for children on the autism spectrum? *Personal Ubiquitous Comput.*, 16, 2 2012), 129-141.

[10] Schachter, S. and Singer, J. Cognitive, social, and physiological determinants of emotional state. *Psychological review*, 69, 5 1962, 379.

[11] Koo, H. 'TellMe': therapeutic clothing for children with autism spectrum disorder (ASD) in daily life. In *Proceedings of the Proceedings of the 2014 ACM International Symposium on Wearable Computers: Adjunct Program* (Seattle, Washington, 2014). ACM.

[12] Kirk, P. 2014. Stress ball in action and sending data! *Musical stroke project*. http://strokeproject.wordpress.com/.