The Interactive Carpet - Smart Textile Interface for Children on Autism Spectrum Disorder

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ABSTRACT
This paper discusses the socializing potential of the smart textile based interface and presents the design and future study method of the Interactive Carpet prototype, designed in cooperation with Autism Spectrum Disorder (ASD) specialists. The future exploratory study will shed a light on the potential effect on social skills of children with ASD and how its physical properties and multi-sensory feedback could promote interaction between caregiver and a child with ASD.

Author Keywords
Autism; Tangible Interactions; Smart Textiles;

INTRODUCTION
Autism Spectrum Disorder (ASD) is a lifelong neurodevelopmental disorder (NDD) characterized by repetitive behaviors and impairment in verbal communication [1, 2]. This paper proposes to investigate tangible properties of smart textiles and incorporate them in building the prototype to help children on low - functioning autism in enhancing social skills and attention.

LITERATURE REVIEW
There is a number of studies on how the technology may assist with intervention practices of kids with NDD, including ASD. A prevailing number of studies investigate various digital applications [6, 8, 12, 13] and how these solutions may help kids on ASD with recognizing emotions, organizing daily routines, and developing empathy. Another body of research investigates how robotic toys may enhance social skills of kids with autism [9]. Other studies are concerned with research of the natural-user interfaces (NUI) and how the whole-body interaction systems may augment sensory-integration therapies and creativity [11]. More so, integrating Tangible User Interfaces (TUIs) into occupational therapies has proven its efficacy in children with ASD [7, 10, 14, 15]. Overall research on integrating TUIs into ASD occupational therapies has shown positive effects for stimulating attention, shortening duration of solitary activities, lowering arousal. That said, to our best of knowledge, there was no thorough study done on the soft interfaces incorporating smart textile technology for autistic children and how the interaction with soft physical objects with multi-sensory feedback may stimulate attention and enhance socializing of children on low-functioning ASD.

TEI '18, March 18–21, 2018, Stockholm, Sweden

ACM ISBN 978-1-4503-5568-1/18/03.
https://doi.org/10.1145/3173225.3173341

GOALS AND OBJECTIVES
This paper proposes to explore different properties of the interactive, textile based prototype and how they may stimulate attention and enhance social skills and promote better child-care giver interaction. Considering the plethora of research on TUIs and sensory integration therapy, we hypothesize, that soft properties of the interface with various sensory feedback and physical soft objects should promote attention and enhance socializing [2, 7, 9, 10].

THE DESIGN OF THE PROTOTYPE
A user centered design method has been used to design and construct first iteration of the prototype (Image 1). First, literature review has been conducted to understand current state of the art concerning integration of TUI's into occupational practices with children on autism. Then, there was a close cooperation with a special educators, and a pediatric neuropsychologist, who 1) were interviewed about needs and requirements for therapeutic practices 2) demonstrated tools and practice and gave overview of typical reactions of children on ASD to specific tools and games, 3) consulted on including specific properties to the prototype and viability of the proposed interactions. In addition, the intervention techniques developed by the Autism Diagnostic Observation Schedule (ADOS – 2) were taken in consideration. Based on the ADOS-2, the prototype will be most appropriate for the age group of 5 – 10 years old children on low-functioning spectrum [3]. The prototype is meant for a caregiver and one child to play at a time.

Image 1. Partial view of the Interactive Carpet prototype.

Materials Used

The Interactive Carpet prototype is constructed of various soft materials, using existing smart textile technologies and practices. The carpet is constructed using conductive thread, conductive textiles, soft buttons, soft pressure sensors, stroke sensors, and regular textiles of various colors and textures. In addition to various soft surfaces, the vibration motors, LEDs and audio has been embedded seamlessly. The logic of the game was implemented with Lilypad Arduino microprocessor. The soft textile based interface provides a broader range of interactions to a child and allows squeeze, stroke, folding and other manipulations. Tangibles provide a safety net for encouraging social interaction as they allow for a broad range of interaction styles [4].

Mix and Match Concept

All physical elements of the game that construct various interactions are detachable. This allows an additional creativity and ability to add new elements to the game. Thus, at the start of the game a child and a caregiver will have a woolen carpet and a box with various elements. On the surface of the carpet there will be signifiers (stitched by thread), outlining the borders of the shapes of the elements which have to be matched by the physical elements provided. The rationale behind this is based on the research and interviews with therapists who identified as one of the favorite activities of kids with autism is to match objects to patterns and colors [2, 3].

Storytelling Interactions

The first iteration of the prototype represents six main interactions. The interactive elements are meant to provoke interaction between caregiver and a child based on the storytelling, associative and cause-effect play. Different elements of the game will require different inputs (touch, pressure, placing objects onto a matching pattern, stroke) and will produce different outputs (light, vibration, sound).

Elements

Family. This element represents a family of three soft dolls which can demonstrate a "happy" emotional state. For instance, if a player attaches a flower to a hand of a doll, its face will show a smile (the smile will light up with LEDs). This element demonstrates a cause – effect interaction.

Rainbow. This is a collaborative element. Two players should place on a carpet the physical object of a sun and of a cloud simultaneously in order to get a rainbow (the embedded LEDs will start blinking).

Fish. This element requires placing an object of a fish onto a signifier and after a gentle pressure onto a fish object a player will receive a vibration feedback under his/her palm.

Grass. This element will require a player to stroke the surface of the soft textile grass. The embedded soft stroke sensor will provide light (via embedded LEDs) feedback upon stroking.

Color Mixing Flower. This element shows different colors and engages into a collaborative play. When two flower petals of different colors are squeezed simultaneously, a new color will be in the center of the flower.

Rain drops and a bird. By placing an element on the momentary pressure switch a sound will start accordingly. If a rain drop is attached to the matching signifier, the sound of the rain will start playing. This element provides an auditory stimulation and a cause-effect play scenario.

The elements are a medium for storytelling and meant to stimulate attention through multi-sensory feedback, and enhance socializing through storytelling and stimulated touch senses of children. The rational of this assumption is based on the previous research which demonstrates that sensory integration techniques, such as pressure-touch can facilitate attention and awareness, and reduce overall arousal [1, 2]. Moreover, there is an abundant evidence that storytelling plays an important role in educational practices for children with NDD [1, 2, 3].

FUTURE EXPLORATORY STUDY

The next phase of the research will be an exploratory study and iterative prototyping to investigate the effect of the Interactive Carpet on social skills and attention of the children with low-functioning ASD in a day care center. The prototype will be given to a caregiver and one child at a time to play for about 30 minutes. Each child will have three sessions of play. The target audience of the prototype are children with low-functioning autism of 5 – 10 years old.

Each play will be videotaped and analyzed against the degree of socializing and attention during the playtime. The degree of socializing will be measured using the variables adopted from the ADOS – 2. Specifically, frequency of the following variables will be coded: eye gaze, joint attention, pointing, and verbal expressions [3]. The attention will be measured through duration of the concentration on each of the six interactions of the prototype. Before testing the prototype with children, the level of cognitive development and autism spectrum of each child should be identified. The pre and post study interviews with the caregivers about each child's behavioral habits will be conducted as well. The results of this type of study cannot be generalized on the bigger population but may suggest useful applications of soft interactive interfaces for ASD occupational purposes, and suggest a need for a bigger study.

CONCLUSION

The Interactive Carpet prototype has been designed in cooperation with ASD specialists and is grounded on the previous research on use of TUIs in ASD therapies [2, 4]. Still, the potential impact of integrating the Interactive Carpet in regular occupational sessions for enhancing socializing and stimulating attention of children with low-functioning ASD has yet to be tested in an empirical study.

REFERENCES

1. American Psychiatric Association. 2013. In *Diagnostic and Statistical Manual of Mental Disorders*. DSM

Library. doi:10.5555/appi.books.9780890425596.x00pre.

2. American Journal of Occupational Therapy, September/October 1999, Vol. 53, 489-497. doi:10.5014/ajot.53.5.489
3. Catherine Lord, PhD, Michael Rutter, MD, et al. 2012. Autism Diagnostic Observation Schedule, Second Edition (ADOS®-2)
4. Rowland, C. M., & Schweigert, P. D. (2009). Object lessons: How children with autism spectrum disorders use objects to interact with the physical and social environments. *Research in Autism Spectrum Disorders*, *3*(2), 517-527. DOI: 10.1016/j.rasd.2008.10.005
5. Laura Benton, Hilary Johnson, Mark Brosnan, Emma Ashwin, and Beate Grawemeyer. 2011. IDEAS: an interface design experience for the autistic spectrum. In CHI '11 Extended Abstracts on Human Factors in Computing Systems (CHI EA '11). ACM, New York, NY, USA, 1759-1764. DOI=http://dx.doi.org.ezproxy.tlu.ee/10.1145/1979742.1979841
6. Cong Chen, Ajay Chander, Kanji Uchino, and Kimiko Ryokai. 2016. Guided Play: Automatic Stereotypical Behavior Analysis and Intervention during Play. In Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts (CHI PLAY Companion '16). ACM, New York, NY, USA, 109-115. DOI: https://doi-org.ezproxy.tlu.ee/10.1145/2968120.2987727
7. William Farr, Nicola Yuill, Eric Harris, and Steve Hinske. 2010. In my own words: configuration of tangibles, object interaction and children with autism. In *Proceedings of the 9th International Conference on Interaction Design and Children* (IDC '10). ACM, New York, NY, USA, 30-38. DOI=http://dx.doi.org.ezproxy.tlu.ee/10.1145/1810543.1810548
8. Franca Garzotto, Mirko Gelsomini, Daniele Occhiuto, Vito Matarazzo, and Nicolò Messina. 2017. Wearable Immersive Virtual Reality for Children with Disability: a Case Study. In *Proceedings of the 2017 Conference on Interaction Design and Children* (IDC '17). ACM, New York, NY, USA, 478-483. DOI: https://doi-org.ezproxy.tlu.ee/10.1145/3078072.3084312
9. Mirko Gelsomini, Giulia Leonardi, Marzia Degiorgi, Franca Garzotto, Simone Penati, Jacopo Silvestri, Noëlie Ramuzat, and Francesco Clasadonte. 2017. Puffy - an Inflatable Mobile Interactive Companion for Children with Neurodevelopmental Disorders. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (CHI EA '17). ACM, New York, NY, USA, 2599-2606. DOI: https://doi-org.ezproxy.tlu.ee/10.1145/3027063.3053245
10. Eva Hornecker and Jacob Buur. 2006. Getting a grip on tangible interaction: a framework on physical space and social interaction. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '06), Rebecca Grinter, Thomas Rodden, Paul Aoki, Ed Cutrell, Robin Jeffries, and Gary Olson (Eds.). ACM, New York, NY, USA, 437-446. DOI=http://dx.doi.org.ezproxy.tlu.ee/10.1145/1124772.1124838
11. Kathryn E. Ringland, Rodrigo Zalapa, Megan Neal, Lizbeth Escobedo, Monica E. Tentori, and Gillian R. Hayes. 2014. SensoryPaint: a natural user interface supporting sensory integration in children with neurodevelopmental disorders. In CHI '14 Extended Abstracts on Human Factors in Computing Systems (CHI EA '14). ACM, New York, NY, USA, 1681-1686. DOI=http://dx.doi.org.ezproxy.tlu.ee/10.1145/2559206.2581249
12. Harini Sampath, Ravi Agarwal, and Bipin Indurkhya. 2013. Assistive technology for children with autism - lessons for interaction design. In Proceedings of the 11th Asia Pacific Conference on Computer Human Interaction (APCHI '13). ACM, New York, NY, USA, 325-333. DOI=http://dx.doi.org.ezproxy.tlu.ee/10.1145/2525194.2525300
13. Will Simm, Maria Angela Ferrario, Adrian Gradinar, and Jon Whittle. 2014. Prototyping 'clasp': implications for designing digital technology for and with adults with autism. In *Proceedings of the 2014 conference on Designing interactive systems* (DIS '14). ACM, New York, NY, USA, 345-354. DOI: https://doi-org.ezproxy.tlu.ee/10.1145/2598510.2600880
14. Karanya Sitdhisanguan, Nopporn Chotikakamthorn, Ajchara Dechaboon, and Patcharaporn Out. 2012. Using tangible user interfaces in computer-based training systems for low-functioning autistic children. *Personal Ubiquitous Comput.* 16, 2 (February 2012), 143-155. DOI=http://dx.doi.org.ezproxy.tlu.ee/10.1007/s00779-011-0382-4
15. Lilia Villafuerte, Milena Markova, and Sergi Jorda. 2012. Acquisition of social abilities through musical tangible user interface: children with autism spectrum condition and the reactable. In CHI '12 Extended Abstracts on Human Factors in Computing Systems (CHI EA '12). ACM, New York, NY, USA, 745-760. DOI: http://dx.doi.org.ezproxy.tlu.ee/10.1145/2212776.2212847