Concept Design for Family Well-being with Knitted Touch Sensors and Augmented Reality

SHRUTI MAHAJAN, Worcester Polytechnic Institute, USA
DENISA QORI MCDONALD, College of Computing and Informatics, Drexel University, USA
RICHARD VALLETT, Center for Functional Fabrics, Drexel University, USA
FANNIE LIU, Snap Inc, USA
GILLIAN SMITH, Worcester Polytechnic Institute, USA
ERIN T. SOLOVEY, Worcester Polytechnic Institute, USA

Communicating emotions and spending quality time with parents is an essential component of childrens' well-being. This need has been highlighted and amplified due to the elevated mental health issues during the COVID-19 pandemic. Existing technology found in our homes, such as smartphones, often replaces quality time or creates distractions that take away from communication and connection within families. Tangible interactive technologies, on the other hand, can be integrated into the home environment and can support ambient awareness. Thus, we present a prototype using touch-sensitive fabrics and augmented reality (AR) visuals to create an interactive environment for co-located parent-child communication that encourages emotional awareness, co-play and bonding.

1 INTRODUCTION

The COVID-19 pandemic has affected the mental well-being of families deeply, with negative effects including isolation, conflicts due to communication problems, boredom, and stress due to absence of child-care. Several studies have reported a rise in mental health issues in children and strains in parent-child relationships during the pandemic [3, 8, 21–23]. Our goal is to promote the well-being of children by building technologies that encourage co-play and communication between parents and children in the post-pandemic future, using tangible soft knitted sensors and augmented reality. We are inspired by tangible objects that children use in their daily life for emotional support and expression, as well as practices for social-emotional learning that are used in schools. For example, in schools, teachers use tangible objects such as feeling sticks to encourage children to talk about conflicts in a calm manner. At home, children often use security blankets or toys as tools for emotional self-regulation. We are interested in investigating how tangible technology can support well-being in children by encouraging co-play and helping parents and children have emotional check-in conversations. Specifically, we explore the use of tangible soft knitted sensors for supporting touch and warmth during these interactions, and augmented reality for promoting self-expression through visualization. Informed by prior work, we design for pleasure, social well-being and self-expression aspects of mental well-being[25]. We target interactions with children aged 9-12 due to their ability to understand, label and predict their mixed and subtle emotions[18]. In this paper, we describe our design work thus far, including our initial proof of concept design and formative user studies.

Authors' addresses: Shruti Mahajan, Worcester Polytechnic Institute, 100 Institute Rd, Worcester, Massachusetts, USA; Denisa Qori McDonald, College of Computing and Informatics, Drexel University, 3675 Market St., Philadelphia, Pennsylvania, USA; Richard Vallett, Center for Functional Fabrics, Drexel University, 3101 Market St., Philadelphia, Pennsylvania, USA; Fannie Liu, Snap Inc, Seattle, Washington, USA; Gillian Smith, Worcester Polytechnic Institute, 100 Institute Rd, Worcester, Massachusetts, USA; Erin T. Solovey, Worcester Polytechnic Institute, 100 Institute Rd, Worcester, Massachusetts, USA.

Fig. 1. Parents and child interacting with a prototype integrated into different home contexts: *a)* Dinner table *b)* Couch *c)* Blanket

2 BACKGROUND AND RELATED WORK

Social-Emotional Learning: Social-Emotional Learning (SEL) curricula such as CASEL (Collaborative for Academic, Social, and Emotional Learning)[1], and the RULER (Recognizing, Understanding, Labeling, Expressing, Regulating)[2] [10] research focuses on teaching skills that foster better emotional skills in children. These skills can lead to overall better mental health and well-being. They use mood meters to teach children about recognizing and labeling their own emotions, and surveys to analyze children's wellness and feelings about school and class environments [5]. Emotional awareness, or the ability to recognize and describe self and others' emotions, is one such skill taught to children as a part of the SEL curriculum. Children can greatly benefit from practice and demonstrations on how to apply these skills outside school, at home and in real life with parent involvement [17]. Slovak et al. [24] summarize the current challenges in SEL, especially challenges regarding parent involvement that relate to time, interest and perceived value largely rooted in unfamiliarity. They outline how these could be addressed by digital technology, thus providing a basis for a strong HCI research agenda in this space. In our work, we hope to create tangible interfaces that encourage parent involvement by reducing time/location related challenges and increasing parent interest and awareness, while also enriching childrens' socio-emotional learning through transfer to a home environment.

Soft Machine Knitted Fabric Touch Sensors: Capacitive machine knitted fabric sensors are easy to manufacture, scalable, and have design variability [15, 26, 27]. Currently, fabric-based touch and pressure sensors are being explored for use in many different settings, such as smart homes [30], healthcare [1, 2, 12], wearable devices [29, 31], and accessibility [6, 28]. One of the main benefits of using touch-sensitive fabrics is their potential to be seamlessly integrated into various environments in intuitive and non-intrusive ways. Recent work investigates user perceptions and everyday use when interacting with touch-sensitive knitted fabrics [14]. User perceptions demonstrate that they are ideal for children due to their soft, flexible and portable nature. While prior researchers have explored their use in free play, specific games, and storytelling with children [6, 16, 28], we study how knitted touch sensitive fabrics can support children's well-being through emotional expression and their communication with parents.

Augmented Reality Environments for Children: Augmented Reality (AR) provides an opportunity for creating playful, immersive and interactive environments for children [9, 19]. For example, EmoFindAR [13] is a Mobile AR game, shown to increase children's emotional awareness, played in collaborative and competitive modes with friends to find emoticons and interact with them in a room. Additionally, there is evidence that adding tangibility to AR ("Tangible AR") satisfies user need for direct manipulation. For example, Hutchins et al. [11] show that such tangibility can help users focus on the goal rather than the process, and has been applied in education and learning settings [4, 7, 20]. We are exploring if a tangible AR environment can similarly improve focus on emotions, increasing emotional awareness.

[1]CASEL: https://casel.org/
[2]RULER:https://www.rulerapproach.org/

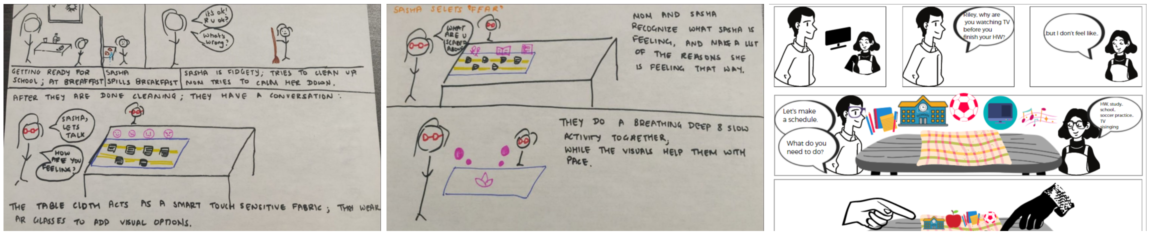

Fig. 2. Storyboards: *(a and b)*: These show a parent and child using the system for breathing exercises to help the child calm down. *(c)*: Shows a parent and child using the system to create a schedule for the child.

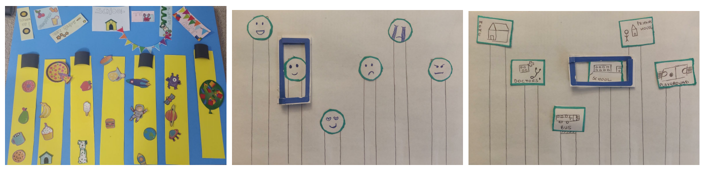

Fig. 3. Paper Prototypes *(a)*: This paper prototype contains several movable components depicting animated objects that will be a part of the AR *(b)*: The emoticons represent different emotions user can chose from. These will be displayed through AR. *(c)*: The emoticons represent different places that user can chose from. These will be displayed through AR.

3 COZYCHAT CONCEPT DESIGN

To explore the potential for tangible AR to support parent-child communication and, subsequently, children's well-being, we created CozyChat. CozyChat is a tangible embodied interactive environment with a smart cozy fabric and SnapChat augmented reality lens with animations depicting objects/places/emotions (Fig 5). CozyChat consists of machine knitted fabric sensors (see samples in Fig 4), created at the Drexel University's Pennsylvania Fabric Discovery Center at the Center for Functional Fabrics, and a Snapchat Lens that detects and displays AR visualizations on top of the fabric. As a knitted sensor, this system can be integrated into various fabric items, such as children's clothes, blankets, table placemats, or other furniture. We aim to explore the potential of this technology in different home contexts (Fig 1).

To envision how CozyChat could integrate into parent-child communication, we created several storyboards (Fig. 2) and paper prototypes (Fig. 3) that explored different usage scenarios and visualization options. We also created low-fidelity prototypes to test user interactions with the fabric (Fig 4). Based on this design work, we imagine an interaction where a parent and child view the fabric together through their phones or tablets. The AR view will contain interactive elements such as animated objects and filters. Parents and children can use these elements and interact with them through the fabric to have emotional check-in conversations about their day, talk through problems they might be facing, make mundane scheduling and to-do list tasks more interactive, as well as encourage activities to express themselves such as breathing exercises or playing Whack-a-Mole (Fig. 5).

4 INITIAL PILOT USER STUDY

We conducted a semi-structured pilot interview to get initial feedback from a participant aged 11. The participant interacted with the sensor and watched a demonstration video of our low-fidelity prototype (Fig 4). We asked the participant their perceptions on potentially using such a system to communicate with their parent.

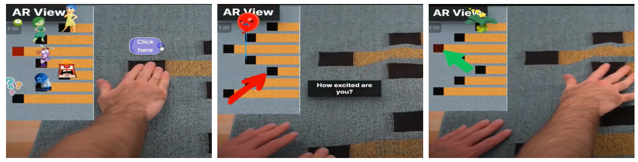

Fig. 4. Low Fidelity Prototypes were created using an interactive video editing software. Emoticons and movie characters are used to prompt the child about how they are feeling. The child here answers "Excited" and can express how excited they are feeling by controlling the visuals with a swipe across the touch sensitive areas

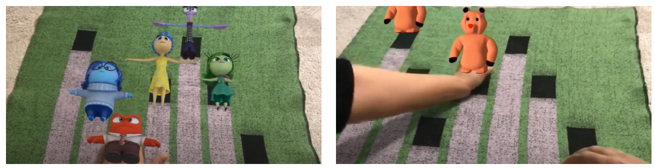

Fig. 5. High fidelity prototypes of SnapChat augmented reality lens and knitted blanket with black touch-sensitive areas *(a)*: AR characters to help children label their emotion *(b)*: Whack-a-mole game

The participant provided several suggestions to make the system more engaging and interactive for emotional communication between parents and children. They suggested having the AR elements change on or around the users to make the face-to-face interaction more fun than a regular conversation. They also suggested that certain phrases such as “How are you?” or sounds such as laughing could be detected to trigger appropriate activities to enhance the conversation. Moreover, they said that adding color filters to depict current mood may create a more immersive setting and enable users to keep focus. Additionally, the participant suggested adding virtual pets that users can chase and pet during conversations for comfort. Lastly, the participant stressed that the emotional conversation should not be forced on them, indicating a need to consider how and when children want to talk about their feelings. They suggested that end-user customization could support this by making the topics and locations more relevant to the users.

5 DISCUSSION AND FUTURE WORK

This work-in-progress explores how the use of knitted touch sensors and AR has the potential to support co-located parent-child well-being. Building this technology presents several challenges. One challenge is finding ways to build personalized technology that accommodates the differences in communication and expression styles in children. While the combination of AR and knitted sensors has the potential to create engaging new experiences integrated into the home environment, careful consideration must be given to keep the focus on the users, their feelings and conversations, and not on the technology. In the future, we hope to involve parents, children and child psychology experts in participatory design to address these challenges and create a portable environment that helps foster parent and children emotional well-being and relationships. We hope that such technologies can encourage parents and children to communicate and promote their emotional well-being in the post pandemic future.

ACKNOWLEDGMENTS

We thank the members of Drexel University’s Pennsylvania Fabric Discovery Center at the Center for Functional Fabrics for their invaluable digital knitting expertise. We would also like to thank Prof Ali Shokoufandeh and Prof Geneviève Dion for their support. Lastly, we thank Snap Inc for supporting this research.

REFERENCES

[1] Asli Atalay, Ozgur Atalay, Muhammad D Husain, Anura Fernando, and Prasad Potluri. 2017. Piezofilm yarn sensor-integrated knitted fabric for healthcare applications. *Journal of Industrial Textiles* 47, 4 (2017), 505–521.

[2] Ozgur Atalay. 2018. Textile-based, interdigital, capacitive, soft-strain sensor for wearable applications. *Materials* 11, 5 (2018), 768.

[3] W Steven Barnett and Kwanghee Jung. 2021. Seven impacts of the pandemic on young children and their parents: Initial findings from NIEER's December 2020 preschool learning activities survey. *National Institute for Early Education Research* (2021).

[4] Mark Billinghurst, Raphaël Grasset, Hartmut Seichter, and Andreas Dünser. 2009. Towards ambient augmented reality with tangible interfaces. In *International conference on human-computer interaction*. Springer, 387–396.

[5] Marc A Brackett, Craig S Bailey, Jessica D Hoffmann, and Dena N Simmons. 2019. RULER: A theory-driven, systemic approach to social, emotional, and academic learning. *Educational Psychologist* 54, 3 (2019), 144–161.

[6] Rachael Bevill Burns, Hasti Seifi, Hyosang Lee, and Katherine J Kuchenbecker. 2021. Getting in touch with children with autism: Specialist guidelines for a touch-perceiving robot. *Paladyn, Journal of Behavioral Robotics* 12, 1 (2021), 115–135.

[7] Pedro Campos and Sofia Pessanha. 2011. Designing augmented reality tangible interfaces for kindergarten children. In *International Conference on Virtual and Mixed Reality*. Springer, 12–19.

[8] Ieva Daniunaite, Inga Truskauskaite-Kuneviciene, Siri Thoresen, Paulina Zelviene, and Evaldas Kazlauskas. 2021. Adolescents amid the COVID-19 pandemic: a prospective study of psychological functioning. *Child and adolescent psychiatry and mental health* 15, 1 (2021), 1–10.

[9] Lizbeth Escobedo, Monica Tentori, Eduardo Quintana, Jesus Favela, and Daniel Garcia-Rosas. 2014. Using augmented reality to help children with autism stay focused. *IEEE Pervasive Computing* 13, 1 (2014), 38–46.

[10] Jessica D Hoffmann, Marc A Brackett, Craig S Bailey, and Cynthia J Willner. 2020. Teaching emotion regulation in schools: Translating research into practice with the RULER approach to social and emotional learning. *Emotion* 20, 1 (2020), 105.

[11] Edwin L Hutchins, James D Hollan, and Donald A Norman. 1985. Direct manipulation interfaces. *Human–computer interaction* 1, 4 (1985), 311–338.

[12] Ewa Korzeniewska and Andrzej Krawczyk. 2019. Applications of smart textiles in electromedicine. In *2019 19th International Symposium on Electromagnetic Fields in Mechatronics, Electrical and Electronic Engineering (ISEF)*. IEEE, 1–2.

[13] Lissette López-Faican and Javier Jaen. 2020. EmoFindAR: Evaluation of a mobile multiplayer augmented reality game for primary school children. *Computers & Education* 149 (2020), 103814.

[14] Denisa Qori McDonald, Shruti Mahajan, Richard Vallett, Geneviève Dion, Ali Shokoufandeh, and Erin Solovey. 2022. Interaction with Touch-Sensitive Knited Fabrics: User Perceptions and Everyday Use Experiments. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems (CHI '22)*.

[15] Denisa Qori McDonald, Richard Vallett, Erin Solovey, Geneviève Dion, and Ali Shokoufandeh. 2020. Knitted Sensors: Designs and Novel Approaches for Real-Time, Real-World Sensing. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* 4, 4 (2020), 1–25.

[16] Deysi Helen Ortega, Franceli Linney Cibrian, and Mónica Tentori. 2015. BendableSound: a fabric-based interactive surface to promote free play in children with autism. In *Proceedings of the 17th International ACM SIGACCESS Conference on Computers & Accessibility*. 315–316.

[17] Evanthia N Patrikakou and Amy R Anderson. 2005. *School-family partnerships for children's success*. Teachers College Press.

[18] Francisco Pons, Paul L Harris, and Marc de Rosnay. 2004. Emotion comprehension between 3 and 11 years: Developmental periods and hierarchical organization. *European journal of developmental psychology* 1, 2 (2004), 127–152.

[19] Emmanuelle Richard, Valérie Billaudeau, Paul Richard, and Gilles Gaudin. 2007. Augmented reality for rehabilitation of cognitive disabled children: A preliminary study. In *2007 virtual rehabilitation*. IEEE, 102–108.

[20] Rafael Alves Roberto, Daniel Queiroz de Freitas, Francisco Paulo Magalhães Simões, and Veronica Teichrieb. 2013. A Dynamic Blocks Platform Based on Projective Augmented Reality and Tangible Interfaces for Educational Activities. In *2013 XV Symposium on Virtual and Augmented Reality*. 1–9. https://doi.org/10.1109/SVR.2013.11

[21] M Sharma, P Idele, A Manzini, CP Aladro, A Ipince, G Olsson, P Banati, and D Anthony. 2021. Life in Lockdown: Child and Adolescent Mental Health and Well-Being in the Time of COVID-19. *UNICEF* (2021).

[22] Margaret H Sibley, Mercedes Ortiz, Larissa M Gaias, Rosemary Reyes, Mahima Joshi, Dana Alexander, and Paulo Graziano. 2021. Top problems of adolescents and young adults with ADHD during the COVID-19 pandemic. *Journal of psychiatric research* 136 (2021), 190–197.

[23] Shweta Singh, Deblina Roy, Krittika Sinha, Sheeba Parveen, Ginni Sharma, and Gunjan Joshi. 2020. Impact of COVID-19 and lockdown on mental health of children and adolescents: A narrative review with recommendations. *Psychiatry research* 293 (2020), 113429.

[24] Petr Slovák and Geraldine Fitzpatrick. 2015. Teaching and developing social and emotional skills with technology. *ACM Transactions on Computer-Human Interaction (TOCHI)* 22, 4 (2015), 1–34.

[25] Anja Thieme, Jayne Wallace, Thomas D Meyer, and Patrick Olivier. 2015. Designing for mental wellbeing: towards a more holistic approach in the treatment and prevention of mental illness. In *Proceedings of the 2015 British HCI Conference*. 1–10.

[26] Richard Vallett, Denisa Qori McDonald, Genevieve Dion, Youngmoo Kim, and Ali Shokoufandeh. 2020. Toward Accurate Sensing with Knitted Fabric: Applications and Technical Considerations. 4, EICS (2020). https://doi.org/10.1145/3394981

[27] Richard Vallett, Ryan Young, Chelsea Knittel, Youngmoo Kim, and Geneviève Dion. 2016. Development of a Carbon Fiber Knitted Capacitive Touch Sensor. *MRS Advances* 1, 38 (2016), 2641–2651. https://doi.org/10.1557/adv.2016.498

[28] Vianey Vazquez, Carlos Cardenas, Franceli L Cibrian, and Mónica Tentori. 2016. Designing a musical fabric-based surface to encourage children with Autism to practice motor movements. In *Proceedings of the 6th mexican conference on human-computer interaction*. 1–4.

[29] Te-Yen Wu, Shutong Qi, Junchi Chen, MuJie Shang, Jun Gong, Teddy Seyed, and Xing-Dong Yang. 2020. Fabriccio: Touchless gestural input on interactive fabrics. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. 1–14.

[30] Bo Zhou, Monit Shah Singh, Sugandha Doda, Muhammet Yildirim, Jingyuan Cheng, and Paul Lukowicz. 2017. The carpet knows: Identifying people in a smart environment from a single step. In *2017 IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom Workshops)*. IEEE, 527–532.

[31] Mengjia Zhu, Amirhossein H Memar, Aakar Gupta, Majed Samad, Priyanshu Agarwal, Yon Visell, Sean J Keller, and Nicholas Colonnese. 2020. Pneusleeve: In-fabric multimodal actuation and sensing in a soft, compact, and expressive haptic sleeve. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. 1–12.