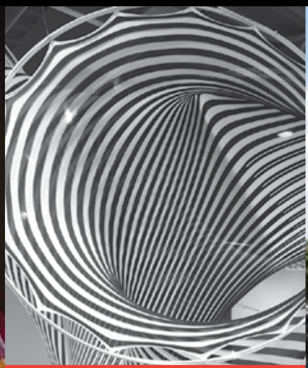
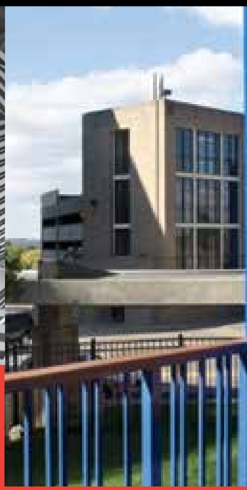
no. 18

Academy Journal 2016


AIA Knowledge Community
Academy of Architecture for Health

Mission of the *Academy Journal*

As the official journal of the AIA Academy of Architecture for Health (AAH), this publication explores subjects of interest to AAH members and others involved in the fields of healthcare architecture, planning, design, and construction. The goal is to promote awareness, educational exchange, and advancement of the overall project delivery process and building products.

About AAH

AAH is one of 21 member communities of The American Institute of Architects (AIA). AAH is unique in the depth of its collaboration with professionals from all sectors of the healthcare community including physicians, nurses, hospital administrators, facility planners, engineers, managers, healthcare educators, industry and government representatives, product manufacturers, healthcare contractors, specialty subcontractors, allied design professionals, and healthcare consultants.

AAH currently consists of approximately 6,954 members. Its mission is to improve both the quality of healthcare design and the design of healthy communities by developing, documenting, and disseminating knowledge; educating design practitioners and other related constituencies; advancing the practice of architecture; and affiliating and advocating with others that share these priorities.

Please visit our website at aia.org/aah for more about our activities. Please direct any inquiries to aah@aia.org.

CONTENTS

no. 18

Academy Journal 2016

AIA Knowledge Community
Academy of Architecture for Health

Textile Environments and Tactile Interfaces
Responsive Multisensory Architectures for Children with Autism Spectrum Disorder

Sean Ahlquist
Assistant professor of architecture, University of Michigan,
Taubman College of Architecture and Urban Planning

ABSTRACT

Children with Autism Spectrum Disorder (ASD) are challenged by issues related to communication, social interaction, and behavioral regulation. In many cases, the inability to properly filter and process sensory information drives these diminished capabilities, causing them to become overwhelmed by their environment and preventing the ability to engage and learn. This paper describes the development of two prototypes, StretchCOLOR and StretchPLAY, part of the Social Sensory Surfaces research project, which focuses on the design of multisensory environments for children with ASD.

The research aims to develop environments that help provide a behaviorally-regulated experience for children with ASD by catering to their specific strengths and interests. Textiles are utilized as both structure and elastic tactile interface, providing a visually and physically engaging environment. The structure is defined as a textile hybrid system—a tent-like structural system integrating tensile surfaces with flexible composite rods. The textile is tailored for both structural capacity and responsiveness to touch by using advanced CNC knitting technology. When tensioned, the textile is activated as a tangible interface where sensing of touch and pressure triggers visual and auditory feedback while providing a positive physical responsiveness in the elasticity and resistance of the textile. This project involves intense collaboration in academia and practice between the fields of architecture, computer science, information science, performing arts and civil engineering, along with practitioners in the field of ASD-based therapies. This paper will describe research in material fabrication and interaction design as well as provide initial results from the use of the prototypes within the setting of local therapy centers working with children who have ASD.

Introduction

This research involves the development of textile-based structures with tactile, visual, and auditory interactions, tailored to address both strengths and challenges for children with ASD. Material experimentation focuses on new methods for constructing lightweight pre-stressed structures as robust systems that can serve as playscapes—spaces for climbing over, across, and within. This involves research in CNC machine knitting—fabricating seamless textiles that when tensioned have a designed responsiveness to pressure at the scale of the hand as well as the scale of the body. Additionally, the development of a new material method for generating large-scale frames of glass-fiber reinforced polymer (GFRP) rods enables the deflection under significant point loads to be greatly minimized while maintaining a slight material profile.

The resulting structure, which interconnects the GFRP rod structure and tensile surface, is equipped with sensing technology to produce a tangible interface where the physical properties of being able to push and stretch the textile act as inputs for interactions with visual and auditory feedback. The overall spatial design and tactile qualities are tailored to address challenges for children with ASD in physical movement and social interaction.

The physiological and behavioral observations of a single child, a five year-old girl named "Anna," serve as the source for specific tuning of the range of feedback parameters including the scale, geometry, and tactile responsiveness of the structures. These concepts regarding material innovation and physical engagement are showcased in the construction and implementation of two prototypes termed StretchCOLOR and StretchPLAY (figure 1).

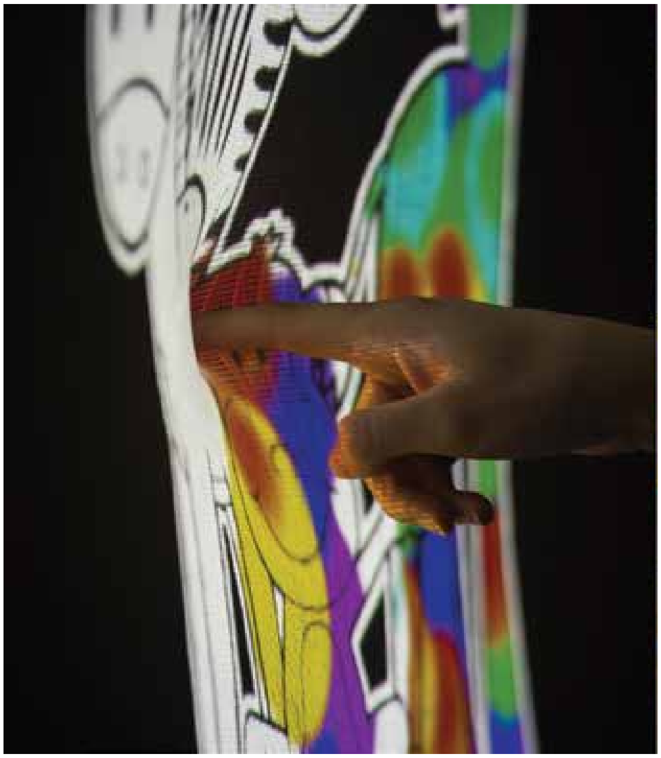


FIGURE 1. Prototypes for technology-embedded playscapes: StretchCOLOR (left), a depth-sensing 2D textile surface for coloring and StretchPLAY (right), a large-scale interactive 3D structure for collaborative play. Image credit: Sean Ahlquist/University of Michigan, Taubman College of Architecture and Urban Planning

Autism and sensory processing

The Centers for Disease Control and Prevention currently estimates that 1 in 68 children are affected with ASD (Baio, 2014). ASD can be defined, in simple terms, as a disorder that can cause significant delays in social, communication, and behavioral development. The range and intensity of these delays can vary greatly from child to child. As a result, among other challenges, the development of learning tools and therapies for children with ASD is quite difficult as they need to be specific and unique to each child. This follows the adage "When you have met a person with autism, you have met exactly one person with autism."

Applied Behavior Analysis (ABA) relies upon observation of behavior and environment, identifying the antecedents and environmental influences that foster desirable behaviors (Myers and Plauché Johnson, 2007). A more specific approach, such as the Play and Language for Autistic Youngsters (PLAY) Project, focuses on developing social behaviors between parent and child using play as the primary motivation while integrating layers of back and forth communication (Solomon et al., 2007). Embedded within ABA-based therapies, which examine and address the specific behaviors of each child, is the understanding of the necessity for first defining a regulating environment, at which point only then can engagement and learning begin.

This research project is directed specifically at issues with sensory processing, the inability of the nervous system to filter certain sensory inputs in order to determine an appropriate response. This can be referred to as a "traffic jam" of sensory data where the intensity of such unfiltered information leads to an over-intensified sensory experience and, ultimately, a dysregulated state.

Difficulties with sensory processing are commonplace in children with ASD. Accordingly, the design of a sensory regulating environment is pivotal as it will influence a child's abilities for self-regulation, movement, learning, and interaction with other (Allen et al., 2011). This can be broken down into results in two categories: Sensory modulation, where ability to grade/regulate response to sensory input is diminished and apraxia/dyspraxia, where motor planning for skills such as speech is also diminished (Miller et al., 2007).

This research takes a close look at the ramifications of apraxia in children with ASD. Apraxia is a breakdown in the sending of messages from the brain to the motoric articulators, the muscles needed to perform specific auditory sounds (verbal apraxia) and control movements (limb/motor dyspraxia) (Ming, 2007; Ballard, 2000). A lack of muscle tone, or hypertonia, also can be common, leading to general imbalance and difficulty in sensing one's position in space, referred to as proprioception.

Behaviorally, the combination of these issues can result in sensory seeking, which may be accomplished with movements such as flapping hands or spinning. The intensity of movement overcomes the diminished sensory processing and allows for the sensation and understanding of where the limbs and body are positioned in space. It is important to understand, in the context of this research, that sensory processing disorder does not directly entail sensory sensitivities or overstimulation.

This research addresses the case where the sensory signals are diminished, resulting in under-stimulation; therefore intensified feedback is necessary in order to register sensory input. In response, the intent is to accomplish strong sensory feedback through the design of tactile, interactive, and immersive environments, with consideration to how the spatial and sensory components can be balanced to address each child's specific issues.

Textile hybrid structures

A primary feature of the StretchPLAY prototype is the implementation of a structural logic, termed textile hybrid, where the overall form is realized through the structural interaction of textiles and GFRP rods akin to a common tent structure (Ahlquist et al., 2013). The tensile surfaces are classified as "form-active," where geometry (or form) is realized only at the moment the material is actively pre-stressed in tension. This

FIGURE 2. Textile hybrid prototypes developed in previous research, utilizing a CNC knitted textile as the tensile surface interconnected with bending-active GFRP rods. Image credit: Sean Ahlquist/University of Michigan, Taubman College of Architecture and Urban Planning

research builds upon the development of previous prototypes utilizing textiles manufactured on CNC knitting machines as the tensile surface in a textile hybrid system (figure 2).

The term bending-active is used to define the elastically bent elements where geometry is based upon deformation from an initially straight configuration, gaining stiffness in its curved and pre-stressed state (Lienhard et al., 2012). Materials that combine high strength with low bending stiffness best serve as bending-active elements.

The textile identifier of a textile hybrid signifies the common material nature of the form-active surface and the bending-active elements, both requiring a particular fiber or textile structure to satisfy the structural loading without plastic deformation. This is termed a hybrid structural logic using the classification system established by Heino Engel, where multiple structural actions are utilized within a single integrated system (Engel, 2007).

The elastic nature of a textile hybrid system is pivotal for the StretchPLAY prototype in designing a lightweight, responsive structure where it's give can be tuned on a local scale through the knit structure of the textile and its form-active nature and on a global scale in the arrangement and structuring of the bending-active GFRP rod network.

CNC machine knitting

This research utilizes the fabrication facilities at University of Michigan, which feature a large-scale CNC knitting machine, a manufacturing device for producing weft-knitted textiles. A key capability of CNC knitting is the production of seamless multilayered and structurally differentiated textiles, a method commonly referred to as 3D knitting (Peterson et al., 2011). A prominent example of these material features is the Flyknit line of Nike shoes, where the entire shape and structure (the upper, excluding the sole) is produced with a single, continuous textile. This reduces significant amounts of material waste while allowing for all the ranges in geometry and structure necessary to be satisfied in a single seamless textile (Hunter, 2013).

For this research, the technology enables the key capability of designing and manufacturing both the structural and tactile quality of the textiles in manners that can be highly articulated. The structural quality for the StretchPLAY prototype reflects its purposing as the tensile surface of a textile hybrid system while also supplying desirable support when climbed upon. The tactile quality, emblematic of the Stretch-COLOR prototype, is focused on the quality of touch and graded resistance to pressure against the textile surface.

Collaborative teaching and interdisciplinary research

The research and prototypes in this project are developed through in-depth collaboration between academia and practice involving architecture, computer science, performing arts technology, and centers focused on specialized therapies for children with Autism. Because each child with ASD has a unique combination of issues, this project focuses on Anna's profile as the basis for forming the technology and architectures. The technology is tailored to Anna's particular sensory profile, addressing both sensory desires and dislikes. In collaboration with the therapists that work with her on a daily basis, a profile was established that focuses on building particular skills in social interaction and motor control.

A unique teaching structure is employed in combining a design seminar in architecture, led by the author, with a capstone software engineering course in computer science led by Dr. David Chesney. Working as interdisciplinary teams, the architecture students focused on designing and manufacturing the textile structures and the computer science students developed technologies for sensing touch and pressure, transforming the textile structures into dynamic interfaces and interactive environments. Collectively, the students developed the interaction design and the concepts for how it addressed the strengths and challenges of Anna's particular neurological and developmental profile.

At the conclusion of the fall semester, the two most successful prototypes were selected for further development (figure 3). The teams involved in developing those projects were the given opportunity during the winter semester to develop final prototypes and implement them at a local therapy center for children with ASD. This unique educational experience gave the students the opportunity to design, build, and deploy their work. They also were able to see it in use, as a part of the daily therapy routine for Anna and other children at the therapy center.

The understanding of ASD and insights into Anna's particular profile were provided by practitioners who worked with Anna on a regular basis. Occupational therapist Cathy Schuh introduced the students to the specific sensory-related issues of grading of movement, which is the inability to utilize the appropriate amount of pressure to perform fine motor tasks. PLAY Project therapist Onna Solomon provided explanations for Anna's successes and challenges in social interaction, particularly related to her being nonverbal. The

FIGURE 3. Project showcase (left) and initial working prototype for StretchCOLOR (right) developed through collaborative courses in architecture and computer science with input from practitioners in autism-based teaching and therapy. Image credit: Sean Ahlquist/University of Michigan, Taubman College of Architecture and Urban Planning

PLAY Project focuses on providing techniques for engaging communication and social interaction through what they term collaborative play.

Onna provided the students with an understanding of the specific techniques that were developed for Anna, where play-based interactions focused on gaining eye contact and waiting for gestural communication in order to complete or continue certain aspects of an activity. Students were given the opportunity to understand and engage in some of these therapeutic approaches through a hands-on playtime session with Anna. Key components of the final two prototypes developed were born of the playtime experiences and observations.

Technology-embedded surfaces and playscapes

StretchCOLOR

The StretchCOLOR prototype focuses on developing skills in fine motor control, particularly the ability to grade movement. Grading of movement is a part of the proprioceptive sense, processing information to both understand the position of limbs and body in space and dictate appropriate movement based upon particular stimuli. Dysfunction in proprioception relates to improper processing of information received through muscles, skin, and joints, accompanied by similar issues related to the tactile sense (Kranowitz, 2005).

In Anna's particular case, she is defined as a sensory seeker who needs deep pressure applied to the joints and more significant skin contact to register and trigger a proprioceptive response. It is often the case, still, that the proprioceptive response is quite crude, meaning the amount of movement or fine motor control is inappropriate (either too much or too little) for a particular task. This defines the challenge in developing technology, which fosters skill building for grading of moment where the proprioceptive sense is not providing the adequate information to dictate an accurate response. As a sensory seeker, Anna exhibits a strong desire to learn through tactile interactions, yet increased sensory feedback is required to activate such interactions.

The elasticity in relation to touch and pressure is a key criterion for the design of the textile in the StretchCOLOR prototype. The quality of resistance in pushing on the tensioned textile is an important feature in order to activate the sense of touch. With difficulties in sensory processing, a strong resistance can be quite beneficial as pressure to the joints beyond just the hand and finger tips produces a better chance for the tactility to be identified and subsequently provides a calming effect (Grandin, 1992). Focusing on this pivotal engagement of deep pressure, the prototype is programmed to read the amount of deformation in the textile as defined

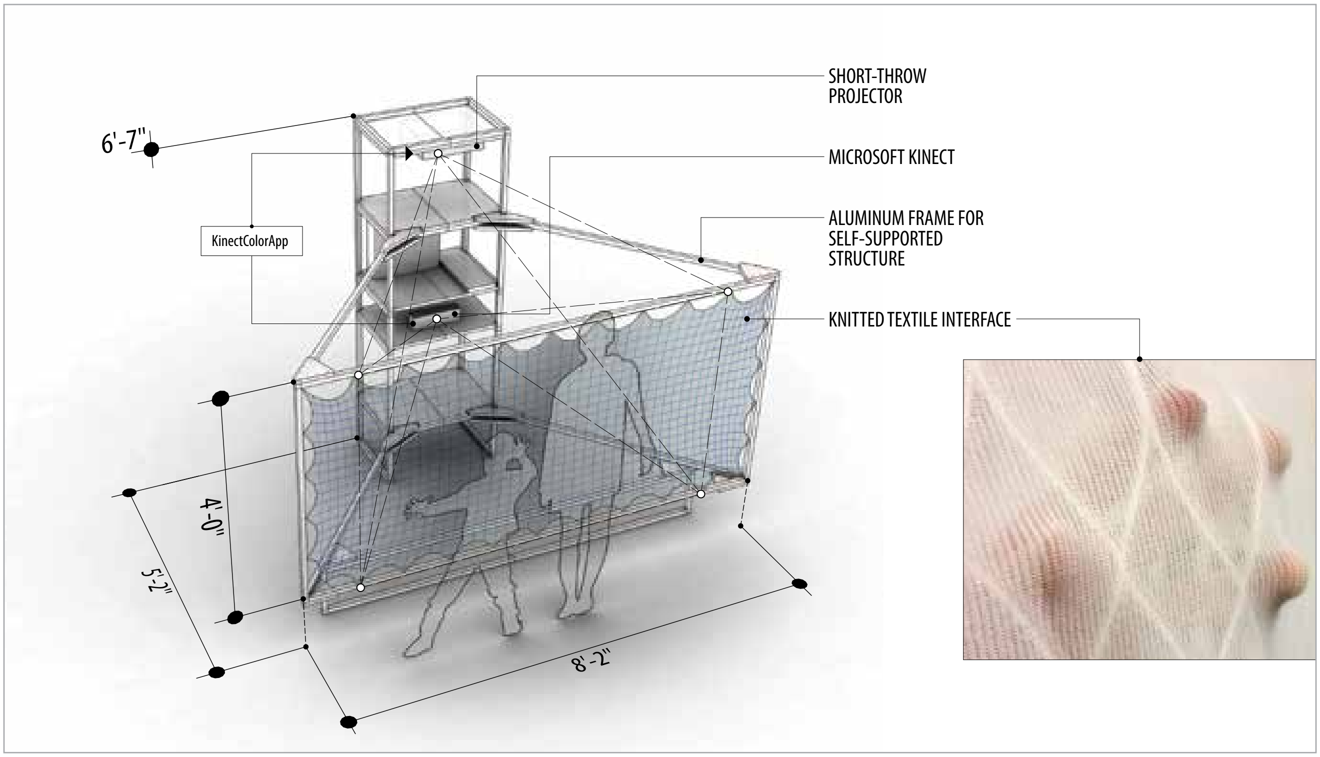


FIGURE 4. Architecture of the StretchCOLOR prototype. Image credit: Sean Ahlquist/University of Michigan, Taubman College of Architecture and Urban Planning

by the depth scanning capabilities of the Microsoft Kinect, which identifies where and how much pressure has been applied (figure 4). In response, a circle of a particular size and color is projected at the point of interaction (figure 5).

The textile is designed to be highly elastic, with an open knit structure using a nylon elastic yarn, in combination with a dense structure that forms a gridded pattern. The elastic nature allows for minimal pressure needed to deform the textile whereas the gridded structure is utilized to inhibit grand sweeping movements across the textile (figure 4, inset). The intention is to form interactions that slow the pace of play, provide intentionality and focus on individual movements, and produce the more desirable physical feedback on the joints, rather than only skin contact, by sweeping across the surface.

StretchPLAY

The overall scale and surface design of the StretchPLAY prototype is based upon examining environments in which Anna is comfortable with play and social interaction. Through the playtime session between Anna and the students mentioned previously, it was seen that Anna has a particular fondness for playing inside automobiles of a certain size. The assessment was that she prefers the smaller interior of a sedan over something like an SUV because she can understand her position within the car based on a constant and close proximity to the exterior surfaces. She was willing to engage people within the car, an environment that could be controlled only allowing a minimal number of people to occupy the small space.

A critical aspect of seeing Anna's comfort in a particular space is identifying her ability to clearly communicate. Through gesturing and signs, such as indicating to play music, close the doors, or drive around, her comfort level within the environment is exhibited. This provides the indication that the environment itself is sensory regulating, not overwhelming, allowing her to focus on her interests and engage in social interaction and communication. As a response to this interpretation, the design of the StretchPLAY structure is based upon the scale of a car interior and loosely references a front seat (the wide tube) where two or more people can interact and a back seat (the narrow tube) as a smaller, more individual space (figure 6).

FIGURE 5. Size and color of the projection, at the point of interaction, changes from red to orange to yellow based upon the amount of pressure applied. Image credit: Sean Ahlquist; University of Michigan, Taubman College of Architecture and Urban Planning

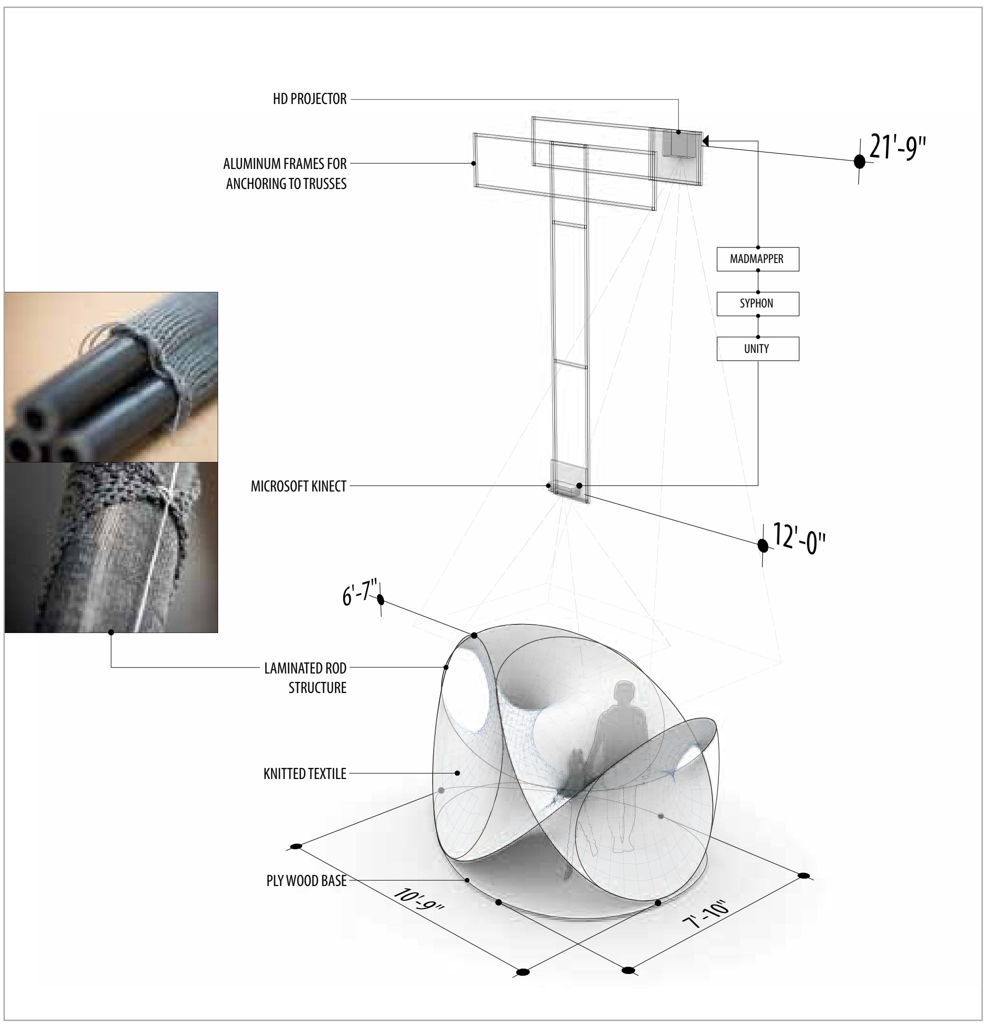


FIGURE 6. Architecture of the StretchPLAY prototype. Image credit: Sean Ahlquist/University of Michigan, Taubman College of Architecture and Urban Planning

The textile hybrid aspect of the prototype advances upon previous research in the fabrication of the rod structure and the complexity in the knitted textile. The demands on the rod structure were significant in comparison to earlier prototypes where the systems were designed primarily for self-structuring and minimal external loading. In this instance, the structure is designed for climbing and is able to withstand a small child pushing, pulling, and traversing along and within the form.

A critical feature, as well, is the stability of the structure. It is necessary that it maintains its geometry and position for purposes of sensing interaction when used with the Microsoft Kinect. The calibration and alignment between where the textile is touched and the projection of the consequent animations requires that the overall shape and location of the structure remain constant (figure 6). For these criteria, the rod structure is a multi-hierarchical system designed as a type of pre-stressed laminated beam construction using an epoxy-impregnated knitted sleeve that is able to minimize deflection in the structure (figure 6, inset).

The interaction design is based on tactile, visual, and auditory feedback in order to build opportunities for social communication. The primary sequence of interaction is to depress the textile to a certain depth in a specific location, referred to here as a trigger, in order to activate an animation projected back onto the structure and play a sound clip synchronized with the contents of the animation (figure 7).

Triggers are dispersed throughout the surface. As an expanded, though critical, aspect of interaction the

FIGURE 7. Animations and sound clips are played when the textile is depressed at certain locations. A pulsing circle is illuminated when a trigger found is found. Certain animations play by activating a single trigger, whereas others play when two triggers are activated simultaneously. Image credit: Sean Ahlquist/University of Michigan, Taubman College of Architecture and Urban Planning

trigger points are initially hidden. This is to encourage traversing the tensioned textile, producing enhanced and extended skin contact and pressing in areas in order to locate the triggers. When a trigger is found, a circle pulses to help reinforce memory of where the activation point is. The effort of finding trigger points ensures an aspect of exploration and also guarantees gross motor movement as a part of the playing process. To integrate coordination as a social exercise, certain animation and sound sequences are activated only when two triggers are pressed simultaneously.

Initial observations and reflections for use of prototypes

The StretchCOLOR prototype has been installed at the Spectrum Therapy Center in Ann Arbor, Mich., and is being used by Anna as well as other children who have ASD, as a part of their daily ABA therapy routine. The first issue in using the technology was finding the right apparatus for Anna to have enough stability to apply pressure to the textile. As mentioned in relation to apraxia is a general imbalance and poor awareness of the position of the body in space. With Anna's instability, devicessuch as a balance board were tested in order to reduce the overall motoric degrees of freedom. Ultimately, having her seated while leaning against the back of the chair allowed her to focus on the movement of her arms and hands, eliminating confusion related to a lack of body awareness (figure 8).

This places a logical, yet significant demand on future development of the architecture of the prototype. Based on Anna's experience with the technology, it's not only the moment of applying pressure to the textile, it's also about the entire spatial experience of first grounding herself in a stable position and then interacting with the technology.

This extends into another observation for using StretchCOLOR to foster social interaction. Where the technology is engaging, it has not been so engrossing as to remove the involvement of the therapist who helps to guide the interactions. Communication has been utilized to initiate joint play and even to provide help in applying the appropriate pressure to control, where physical fatigue may have started (figure 9, left). The scale aids this effect, through the secondary result of the projections being cast onto the floor behind the child. This grand visual often entices the children to pull away from the interface and gaze at the even larger image (figure 9, right).

The StretchPLAY prototype was installed in a gallery as a part of the exhibition of the Social Sensory Surfaces research project. While thorough exposure was not possible in this setting, certain observations were made based on several opportunities Anna had interacting the prototype. Based on input from the PLAY project, the prototype is tailored to develop social skills by reinforcing circles of communication, especially when eye contact is made. By using repeated reinforcements through the means of play, the intent is to build social interaction as a more innate response in

FIGURE 8. Reducing degrees of freedom to provide stability for interaction. Image credit: Adam Smith/University of Michigan, Taubman College of Architecture and Urban Planning

FIGURE 9. Fostering social interactions based on requesting help in applying pressure in order to color (left) and a secondary projection (right) that encourages children to disengage from the primary interactive surface.
Image credit: Bryan Ranallo/University of Michigan, Taubman College of Architecture and Urban Planning

FIGURE 10. Use of StretchPLAY by the study subject, Anna, during the exhibition opening of the Social Sensory Surfaces research project.

Image credit: Adam Smith/University of Michigan, Taubman College of Architecture and Urban Planning

children with ASD for whom this type of interaction is nonexistent, unsettling, or not instinctive.

A compelling moment was seen during the exhibition opening, when Anna exhibited clear communication within a global environment that was greatly overstimulating due to the number of people and noises in the gallery space (figure 10). The qualities of interacting with the textile, viewing the resulting animations, and climbing through the structure were all enticing and led her to communicate through gesturing which aspect she wanted to explore further. The social interaction was embedded as all of these features required an additional participant for them to be experienced; for example,aid in activating the triggers or climbing on the structure to move through it or watching the animations. The back and forth communication becomes embedded: The child can lead the desire to play a certain animation and sound effect, but the adult has the opportunity to control the moment when it is activated, waiting until visual communication is made.

Conclusion

This research presents a view of architecture that necessitates the consideration of how the factors of time and space, the visual and auditory, and the physical and tactile collectively influence the experience of learning. For children who have ASD, these are critical aspects, and the prototypes developed in this research are tailored to respect Anna's strengths in order to help address her challenges.

Further research looks to expand the specificity in which the architectures can focus on the highly individualized profiles of more than one child. The customizability of the knitted textile, in combination with the capacity to program the interactions, provides an avenue for the technologies and environment to be greatly varied and fine-tuned. In addition, research is being pursued to evaluate the efficacy of the prototypes from a more clinical, rather than observational, perspective and to study their use with a broader set of children. This includes collaborating with the fields of kinesiology, to provide measures and comparative tests for fine and gross motor skills such as balance and dexterity, and psychiatry, to examine social performance such as imitation, shared attention, and understanding other's intentions.

Acknowledgments

This research was funded by the Research Through Making grant from the University of Michigan, Taubman College of Architecture and Urban Planning. The primary investigators for the research were Asst. Prof. Sean Ahlquist (U-M Architecture), Dr. David Chesney (U-M Computer Science), and Assoc. Prof. Sile O'Modhrain (U-M School of Music). Additional collaborators included Cathy Schuh (occupational therapist, Spectrum Therapy Center), Onna Solomon (PLAY project therapist), Collin McRae Leix (visual designer, Little Hill Studio), and Dr. Rita Benn (U-M Center for Integrative Medicine). Student researchers included Taylor Boes, Evan Buetsch, Evan Cann, Karen Duan, Patty Hazle, Yu-Jen Lin, Henry Peters, Jason Chao-Chung Yang, and Dalton Zautke.

References

Ahlquist, S., Lienhard, J., Knippers, J., and Menges, A. (2013). Physical and Numerical Prototyping for Integrated Bending and Form-Active Textile Hybrid Structures. In Gengnagel, C., Kilian, A., Nembrini, J., and Scheurer, F. (eds), *Rethinking Prototyping: Proceedings of the Design Modelling Symposium Berlin 2013,* Berlin University of the Arts, 2013, 1–10.

Allen, S., Delport, S.M., and Smith, K. (2011). Sensory processing and Everyday Life. Presented at The National Autistic Society Professional Conference 2011, Manchester, UK, March 2011.

Baio, J. (2014). Prevalence of Autism Spectrum Disorder Among Children Aged 8 Years—Autism and Developmental Disabilities Monitoring Network, 11 Sites, United States, 2010.

Ballard, K., Granier, J., and Robin, D. (2000). Understanding the Nature of Apraxia of Speech: Theory, Analysis, and Treatment. *Aphasiology,* 14 (10): 969–995.

Engel, H. (2007). *Tragsysteme—Structure Systems, Fourth Edition.* Ostfildern: Hatje Cantz.

Grandin, T. (1992). Calming Effects of Deep Touch Pressure in Patients with Autistic Disorder. *Journal of Child and Adolescent Psychopharmacology,* 2 (1): 63–72.

Hunter, B. (2013). NIKE: 80% Less Waste for New Flyknit Lunar1+. Knittingindustry.com, http://www.knittingindustry.com/flat-knitting/nike-80-less-waste-for-new-flyknit-lunar1.

Kranowitz, C. (2005). *The Out-of-Sync Child: Recognizing and Coping with Sensory Processing Disorder.* New York: Penguin Group.

Lienhard, J., Alpermann, H., Gengnagel, C., and Knippers, J. (2012). Active Bending; A Review on Structures Where Bending Is Used as a Self-Formation Process. In *Proceedings of the International IASS Symposium, Seoul, May 2012,* pp. 650–657.

Miller, L., Anzalone, M., Lane, S., Cermak, S., and Osten, E. (2007). Concept Evolution in Sensory Integration: A Proposed Nosology for Diagnosis. *Amercian Journal of Occupational Therapy* 61, 135–140.

Ming, X. (2007). Prevalence of Motor Impairment in Autism Spectrum Disorders. *Brain & Development* (29), 565–570.

Myers, S. M., and Plauché Johnson, C. (2007). Management of Children with Autism Spectrum Disorders. *Pediatrics* 120, 1162–1182.

Peterson, J. et al (2011). Mass Customisation of Flat Knitted Fashion Products: Simulation of The Co-Design Process. AUTEX Research Journal. 11 (1), 6–13.

Solomon, R., Necheles, J., Ferch, C., and Bruckman, D. (2007). Pilot Study of a Parent Training Program for Young Children with Autism: The PLAY Project Home Consultation Program. Autism, 11 (3), 205–224.

Academy of Architecture for Health

an **AIA** Knowledge Community

The American Institute of Architects

1735 New York Avenue, NW
Washington, DC 20006

aia.org