Title
Being in touch with the core of social interaction: Embodied-design for the nonverbal

ISBN
9781732467279

Authors
Chen, RSY
Ninh, A
Yu, B
et al.

Publication Date
2020

Peer reviewed

Being in Touch With the Core of Social Interaction: Embodied-Design for the Nonverbal

Rachel S.Y. Chen, University of California Berkeley,
San Francisco State University, Nanyang Technological University, rachel.chen@berkeley.edu
Arianna Ninh, University of California Berkeley, ariannaninh@berkeley.edu
Betty Yu, San Francisco State University, bettyyu@sfsu.edu
Dor Abrahamson, University of California Berkeley, dor@berkeley.edu

Abstract: The core of human connection is embodied action, with synchrony, coordinated movement, and affective attunement through the body present from infancy. Yet whereas all students have the capacity for co-presence, a common focus of formal educational institutions on spoken language for interaction makes communication inaccessible to some students, thus impeding their participation in learning. As such, toward providing resources for nonverbal autistic students we must ask: *How do we design for inclusive social participation of students with diverse interactional modalities?* This paper outlines the development of an embodied-design solution that centers the dynamic body as the nexus of social interaction, thus reclaiming the natural versatility of multimodal interpersonal communication. The Magical Musical Mat is a domain-general platform that allows people to interact through the non-speaking modalities of touch and sound. It removes interactional asymmetry between diverse interlocutors and surfaces the basic human need and capacity to connect with one another, in school and beyond.

Background and design objective

Social interaction is integral to learning. Whether teacher-to-student or peer-to-peer, learning is inherently situated in social practice (Vygotsky, 1962). Social participation also creates a sense of belonging, an important factor in successful classroom learning (Osterman, 2010). Yet social interaction transpires from the genesis of life, long before it is situated in institutional contexts: even prior to developing spoken language, healthy newborns attend to, and reciprocally attune to others affectively (Trevarthen, 2011).

Whereas participation in social interaction within educational contexts is possible for many people, it is not readily accessible to many autistic individuals, who communicate differently, especially nonverbal individuals. According to the American Psychological Association (2013), a core interactional challenge for some autistic learners lies not in speech and language use, but rather with engagement in social communication and social interactions that then may affect language development outcomes. Moreover, autistic individuals do not lack innate desire for social interaction (Mundy, 2016), only they may realize this desire differently from neurotypical individuals, often via non-dominant sensory modalities, attunements, and practices. Thus, given that verbal modalities dominate classroom interaction, extant social practices compromise nonverbal autistic students.

Design objective

Designing educational tools for nonverbal autistic students therefore poses the following design problem: How do we design for inclusive social participation of students with diverse interactional modalities? We address this question by outlining an embodied-design platform (Abrahamson, 2014) that positions students' dynamic bodies as the nexus of social interaction. This platform, the Magical Musical Mat (MMM), is designed to foster collaborative interaction as a dyad's emergent solution to the situated problem of enacting musical improvisation.

Prior solutions

Prior solutions for nonverbal student interaction have centered around Alternative and Augmentative Communication (AAC) systems, which are tools that serve as an alternative to or augmentation of an individual's speech. For example, AAC solutions include speech generating devices or picture cards for the expression of specific requests (Beukelman & Mirenda, 2013). Although AAC are thus designed to enhance the practical needs of autistic individuals, AAC have yet to meet other vital social-interactional needs and expressions such as 'social closeness' (Holyfield et al., 2017). That is, AAC rationale is predicated on a pervasive approach to autistic communication that emphasizes linguistic form over interactional function (Yu & Chen, in press). As such, whereas AAC systems focus on indexical language structures geared to generate speech, they inherently neglect developmental antecedents of effective communication, such as dyadic joint attention and mutual creation of shared meaning.

AAC's exclusive focus on generating linguistic forms as interaction solutions has borne three negative consequences: (1) AAC interventions have ignored the body's significant communicative role in joint action and spoken conversation: (2) AAC user interfaces are constrained to an array of symbols and grids, whose use is predicated on effective sequencing skills, excellent memory, and motoric dexterity, thus imposing high cognitive and motor demand (Light & McNaughton, 2019); and (3) AAC interventions are prone to configure interactional asymmetry, where the AAC user must accommodate to their interlocutor's communicative modality (speech).

Conceptual framework

MMM ideation, engineering, and implementation follow the *embodied design* framework (Abrahamson, 2014). Embodied design positions joint action as central to interaction. By designing for action and perception, embodied design aims for co-creation, co-manipulation, and sharing of meaning through interacting with artifacts and other individuals (Abrahamson, Flood, Miele, & Siu, 2019). The design of MMM also draws upon the concept of *intercorporeality*, which anchors interaction in bodily being (Meyer et al., 2017), specifically drawing on the notion of *haptic sociality*, wherein touching is theorized as simultaneous embodied engagements that can communicate both close attunement and trust (Goodwin, 2017).

Design solution

The MMM is a domain-general platform that amplifies physical touch between people through sound. When participants step onto their respective floormats and then establish skin contact with one another, they close and thus activate an electronic circuit that triggers aesthetic musical sounds. As participants co-produce different types of touch-based gestures, such as holding hands, striking "high fives," or performing gentle taps, capacitive sensors on the mat detect resistance changes between their bodies. These resistance changes generate a rich diversity of sounds that dynamically evolve along several dimensions, namely pitch variation, speed of notes played, and the ascension and descension of a musical scale. By using the body as a conduit through which interaction can happen, the MMM reclaims one of the basic modalities of communication: touch (cf. Leder, 1990). Haptic exploratory perception has been theorized as a primordial mode of experiencing the world (Gibson, 1977). It is one of the earliest senses to develop, thereafter remaining integral to mundane experience. MMM lowers the communication threshold by amplifying and augmenting touch, thus rendering expressive collaborative activity readily accessible.

Iterative design process

The ongoing project reported in this paper uses the design-based research (DBR) as an approach to fostering and investigating autistic interaction. MMM has undergone two cycles of design iteration since its conception, each cycle involving design, implementation, and evaluation (see Figure 1; diSessa & Cobb, 2014). The iterations have led us to three prototypes. This section outlines each cycle, details how the relevant prototypes developed at each stage, and expounds on the third prototype design. MMM was first designed as a tangible digital interface. A Bare Conductive Touch Board was used as a microcontroller and plugged with a small speaker to play sounds. A defined range of MIDI sounds were programmed to activate in response to values from different levels of resistance between bodies. We chose foot-activated sensors to free the hands for haptic interaction. To conceal and contextualize the sensors, we embedded them in a mat form. It is constructed of yoga mats and copper tapes.

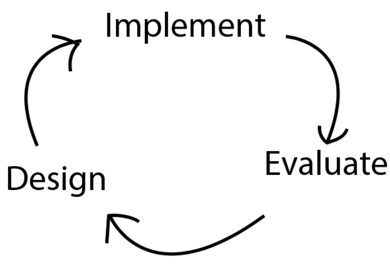

Figure 1. The iterative design cycle.

Design iteration 1—Encountering unanticipated hardware limitations

Our first prototype was installed at a Tangible User Interface showcase at the University of California Berkeley, where students and professors participated in a first pilot study. User interactions on the mat tended towards playful exploration, where users touched each other's arms, faces, and hands in a variety of ways, producing different types of sounds and rhythms. From our first design implementation, we observed that our prototype needed to be robust and durable before further participant usage: the copper tapes were flimsy and rust-prone. Furthermore, several participants who stepped onto our mat had a higher water capacity than others, thus exceeding the resistance range accommodated by the electronic circuit board, resulting in frequent system resets. We improved the MMM accordingly, noting our various implicit assumptions that were now refuted.

Design iteration 2—Material selection, calibration, and robustness

Based on the implementation of our first prototype, we identified some design considerations that had to be addressed. We calibrated our prototype to accommodate to a larger range of resistance values and thus serve a wider variety of bodies. We then sewed our second prototype out of fabric and Velostat, a conductive water-resistant material, so that it would be compact enough for limited classroom storage spaces yet easily washable, safe, and robust enough for long term use.

We introduced the second prototype to an autism clinic that runs Integrated Play Groups (IPG), an interventional form that facilitates students' play-based interactions (Wolfberg et al., 2016). The practitioners presented MMM in two different classes with different age groups (5-8 y/o & 9-12 y/o) and comprising both autistic and neurotypical students. With little guidance, the students interacted with one another in various ways. They played rhythmic hand-games, explored a variety of sounds by touching hands and feet, and took turns pretending to be musical instruments. We had two meetings with the clinic's directors, teachers, and therapists, one directly after the sessions and another a few weeks later. The practitioners expressed surprise at the creativity of the games the students played and the sounds they explored. They also observed a behavioral change in some students, who were at first hyperactive in interacting with each other but had calmed down through using the mat in ways that facilitated other learning activities. Lastly, they stated that the students thereafter continued to express interest in using MMM: they asked the teachers to play with it and mentioned it in later clinic sessions.

A consistent remark we had received from practitioners was that they wanted more flexibility and modularity in the design, so that they could use MMM for diverse activities, within various physical spaces, and with a greater number of students. The practitioners' feedback led us to discern that the possibilities offered by the environment (Gibson, 1977) deeply affect bodily action and thus social interaction. For example, a small physical space would result in haptic interactions that may be more intimate than larger spaces, where participants would have to balance and stretch in order to connect hands. Realizing this significant role of the physical space in shaping social interaction, in turn, surfaced for us a need to design for affordance versatility.

Design iteration 3—Affordance versatility and agency

The third prototype of MMM was modified as adaptable to different physical spaces—small or big—by creating several modular capacitive sensors that can be either pulled apart or placed close together (Figure 2c). This modification creates new interaction possibilities: (1) more than two people can now interact on the mat; (2) users can exercise agency in pulling the mats closer or further apart for different interactions; and (3) the flexibility of the design allows it to be used in different physical spaces. Prototype 3 affords new interaction dimensions to sound expressivity for our next iteration, such as accommodating multi-party interactions or augmenting the scope of touch-based gestures per distance between users. In turn, these new user affordances create new research affordances, such as investigating how architectural dimensions of artifact configurations effect modes of social interaction. Through our work with the autism clinic, we also noted the emergence of rhythmic hand games in the students' interactions. In our next iteration, we plan to include new hard/software functionalities for the augmentation of rhythmic gestures with percussion sounds that will be added to MMM's expressivity repertoire.

a. b. c.

Figure 2. MMM design evolution: (a) Prototype 1: two users, who are each standing on a yoga mat overlaid with copper strips, spontaneously interact to produce emergent musical effects. (b) Prototype 2, equipped with velostat capacitors sewn onto fabric. (c) Prototype 3, a modular design increases affordance versatility.

Discussion

MMM's design cycles iterated the prototypes toward increasing the clarity and durability of its user interface (e.g., robustness, ease-of-use) as well as the scope of its interventional functionalities and outcomes. Through observations and feedback from practitioners, MMM has evolved into a platform of affordance versatility. In turn, we improved our theory and practice so as to include attention to the role of the physical environment in shaping social interaction. In its commitment to designing for inclusive social participation, MMM has embraced touch and sound expressivity to surface interkinesthetic intercorporeality and coordinated action. MMM removes the interaction asymmetry between non/verbal student interlocutors. In designing for this population, we are developing tools not just for autistic interaction, but for embodied interaction at large.

References

Abrahamson, D. (2014). Building educational activities for understanding: An elaboration on the embodied-design framework and its epistemic grounds. *International Journal of Child-Computer Interaction*, *2*(1), 1–16.

Abrahamson, D., Flood, V. J., Miele, J. A., & Siu, Y.-T. (2019). Enactivism and ethnomethodological conversation analysis as tools for expanding Universal Design for Learning: The case of visually impaired mathematics students. *ZDM Mathematics Education, 51*(2), 291–303.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: APA.

Beukelman, D. R., & Mirenda, P. (2013). *Augmentative and alternative communication: Supporting children and adults with complex communication needs* (4 ed.). Baltimore: Brookes Publishing.

DiSessa, A. A., & Cobb, P. (2004). Ontological innovation and the role of theory in design experiments. *The Journal of the Learning Sciences*, *13*(1), 77–103.

Gibson, J. J. (1977). The theory of affordances. In R. Shaw & J. Bransford (Eds.), *Perceiving, acting and knowing: Toward an ecological psychology* (pp. 67–82). Hillsdale, NJ: Lawrence Erlbaum Associates.

Goodwin, M. (2017). Haptic sociality: The embodied interactive construction of intimacy through touch. In C. Meyer, J. Streeck & J. S. Jordan (Eds.), *Intercorporeality: Emerging Socialities in Interaction* (pp. 73-102). New York: Oxford University Press.

Holyfield, C., Drager, K. D., Kremkow, J. M., & Light, J. (2017). Systematic review of AAC intervention research for adolescents and adults with autism spectrum disorder. *Augmentative and Alternative Communication*, *33*(4), 201–212.

Leder, D. (1990). *The absent body*. Chicago: Chicago University Press.

Light, J., McNaughton, D., & Caron, J. (2019). New and emerging AAC technology supports for children with complex communication needs and their communication partners: State of the science and future research directions. *Augmentative and Alternative Communication*, *35*(1), 26–41.

Meyer, C., Streeck, J., & Jordan, J. S. (Eds.). (2017). *Intercorporeality: Emerging socialities in interaction*. New York: Oxford University Press.

Mundy, P. C. (2016). *Autism and joint attention: Development, neuroscience, and clinical fundamentals*. New York: Guilford Publications.

Osterman, K. F. (2010). Teacher practice and students' sense of belonging. In T. Lovat, R. Toomey & N. Clement (Eds.), *International Research Handbook on Values Education and Student Wellbeing* (pp. 239–260). Dordrecht: Springer.

Trevarthen, C. (2011). What is it like to be a person who knows nothing? Defining the active intersubjective mind of a newborn human being. *Infant and Child Development*, *20*(1), 119–135.

Vygotsky, L.S. (1962). *Thought and language*. Cambridge, MA: MIT Press (original work published in 1934).

Wolfberg, P. J., & Schuler, A. L. (1993). Integrated play groups: A model for promoting the social and cognitive dimensions of play in children with autism. *J. of A*utism *and Developmental Disorders*, *23*(3), 467-489.

Yu, B., & Chen, R. S. Y. (in press). Social communication and language development in diverse learners on the autism spectrum. In P. J. Wolfberg & K. D. Buron (Eds.). *Learners on the Autism Spectrum: Preparing highly qualified educators and related practitioners—Instructor manual*. Kansas: AAPC Publishing.

Acknowledgements

This project is supported by the Barbara White Bequest and Jacobs Innovation Catalyst Grant. We thank faculty, therapists, and educators at Project ALLIES, and Kimiko Ryokai and Noura Howell for intellectual contributions.