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A "beyond being there" for VR meetings: envisioning the future of remote work

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1. Introduction

In the 21st century workplace, a great deal of social interaction occurs in meetings. However, research on meetings – and in particular workplace meetings – has long demonstrated the challenges involved in running meetings effectively (Geimer et al., 2015; Hackman & Morris, 1975; Kauffeld & Lehmann-Willenbrock, 2012; Kocsis et al., 2015; Lehmann-Willenbrock et al., 2013; Lehmann-Willenbrock & Kauffeld, 2010; Mroz et al., 2018; Steiner, 1972). Even prior to COVID-19, research identified the increasing role played by remote meeting technology and recognized virtual meetings as an important area of challenge and opportunity for organizations (Allison et al., 2015; Lindeblad et al., 2016). In 2020, surveys of CIOs suggested that the broad shifts to remote (or hybrid) work associated with COVID are likely to continue post-pandemic (Chavez-Dreyfuss, Chavez-Dreyfuss,). An important societal reason for supporting this shift is the need to reduce carbon footprint related to travel, toward the urgent goal of mitigating climate change. As greater demands are placed on remote work, research will need to meet these new challenges.

HCI has a long track record of investigating workplace meetings as a site of intervention and has broadly demonstrated the role that technological mediation can play in supporting interpersonal communication among teams (Bergstrom & Karahalios, 2012, Bergstrom and Karahalios, 2007b; DiMicco et al., 2007, 2004; J. Kim & Shah, 2016; T. Kim et al., 2008; Leshed et al., 2009, 2007, 2010; Pentland et al., 2012; Tausczik & Pennebaker, 2013; Tennent & Jung, 2019). While face-to-face meetings have been shown to be superior to screen-mediated meetings along certain dimensions of proxemics and interpersonal awareness (Kraut et al., 2002), technologically mediated meetings have also been demonstrated to be more effective than face-to face-meetings in certain cases (Gudjohnsen, 2014; Hollan & Stornetta, 1992). Along these lines, Hollan and Stornetta have argued that electronic media are best positioned to support new kinds of communicative affordances rather than imitate "the mechanisms of face-to-face [interaction]" (Hollan & Stornetta, 1992).

The rise of XR (VR, augmented reality, and mixed reality) has brought with it a new set of interactional parameters to explore in shaping social experience (Roth et al., 2019; Slater et al., 2010; Won et al., 2015; Yee & Bailenson, 2007). While social VR experiences currently lack the richness of facial expression cues that can be experienced with video conferencing, some anticipate this gap could be overcome by systems that leverage real-time facial recognition to drive avatar expressions in virtual reality (Cha et al., 2020; Schwartz et al., 2020). Investment in the area of facial recognition by VR industry players like Facebook Reality Labs and DecaGear suggests that commercial innovations may eventually support rich facial expression cues in VR meetings. Likewise, peripheral devices like physical keyboards can be supported in virtual reality (Bovet et al., 2018; Hardawar, 2021), and

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a wide range of virtual desktop sharing features already enable VR users to view their computer screen from within an immersive VR experience.

If social VR is poised to close the gap with video conferencing tools in terms of peripherals and rich facial cues, then researchers can turn attention instead to the unique opportunities that social VR experiences afford – opportunities that set the medium apart from both face-to-face interactions and video conferencing. Social VR, unlike traditional screen-based remote meetings, not only supports aspects of embodied awareness (e.g., a heightened experience of social presence (Smith & Neff, 2018)), but also enables new forms of social interaction that exceed what is possible in face-to-face contexts (J. Bailenson et al., 2008; McVeigh-Schultz & Isbister, 2021; Roth et al., 2019).

However, in many of the examples of contemporary social VR meeting applications and research agendas, we identify a familiar – and seemingly knee jerk – assumption that meetings in VR ought to simply replicate the experience of physical co-presence.[1] Arguing against this tendency nearly three decades ago, Hollan and Stornetta made the case that communication technologies are transformative *not* because they recreate face-to-face encounters, but rather, because they offer new opportunities that go "beyond being there" (Hollan & Stornetta, 1992). More recent research has sought to update this position and reframe "beyond being there" for VR (McVeigh-Schultz & Isbister, 2021; Roth et al., 2019). Building on this work, we propose that social VR meeting experiences could enable more radical departures from familiar social encounters and should instead be thought of as an opportunity to expand the repertoires of social life.

Along these lines, we envision social VR tools that are so helpful that people will choose to use them even when they share physical space. Just as we now might augment a meeting with shared notes in a Google doc, or migrate a physical meeting to a room with a whiteboard, people may choose to 'take the conversation into social VR' because it so effectively supports certain kinds of interactions. In this paper we contextualize this bold claim, and sketch out promising social augmentation design directions toward realizing this future.

In order to make the case for this alternative approach, we synthesize a range of material, from extant practices and affordances to emerging research-through-design work. First, acknowledging the current landscape of commercial VR meeting applications, we contrast this landscape with opportunity areas and nascent practices in the broader social VR media ecology. Then, attempting to harness this wild energy more systematically, we ground our approach in well-established HCI research on sociometric tracking and feedback systems for meetings and contrast this work with existing research on social augmentation in VR. From here, we point to emerging Research-through-Design work that illustrates our approach to supporting what we call 'social superpowers' in VR meetings. Finally, we reflect on key questions that ground inquiry in this area and frame a research agenda for investigating novel social affordances in social VR. If our reader is convinced that there is a research path forward to making social VR useful *even* in contexts of physical co-presence, then our work is done.

2. A 'social superpowers' approach to social augmentation

Research that investigates the impact of perceptual manipulation in VR has shown how design choices can shape social interaction in ways that depart from mirroring 'real life.' Bailenson et al's research on transformed social interaction (TSI) has demonstrated the profound impact that VR can have on social interaction (J. J. Bailenson et al., 2008; J. N. Bailenson et al., 2004). TSI decouples visual feedback from the actual physical behavior of participants' social VR contexts – for example, a teacher can seem to be making eye contact with all their students at once. As a category, TSI covers a range of phenomena including the so-called "Proteus effect," achieved by altering one's avatar form to influence social behavior (Yee & Bailenson, 2007). More recent work in this area includes research on social augmentation in VR. For example, Roth et al. uses hybrid avatar-agent systems to

[1]See (McVeigh-Schultz & Isbister, 2021) for an elaboration on this critique.

manipulate and augment non-verbal social cues in VR (Roth et al., 2019, 2018). This work includes augmentations of hybrid social gaze, leveraging modulations of eye contact, shared attention, and social proxemics (Roth et al., 2018). The powerful effects of these sorts of social augmentations bolster Hollan and Stornetta's position (Hollan & Stornetta, 1992) and update the "beyond being there" position for social VR.

Our research in this area emphasizes the transformative potential of social affordances *perceived simultaneously by multiple participants* (Isbister, 2019; Isbister et al., 2018; McVeigh-Schultz & Isbister, 2021). In preliminary research on this topic in social VR, we have hinted at how novel social affordances can unleash new collective human capacities that we term 'social superpowers' (McVeigh-Schultz & Isbister, 2021). This position is undergirded by a body of research that spans both VR and non-VR work, and examples include: wearables to support conversational balance in meetings (Dagan et al., 2018), playful materials for social affiliation and connection (Márquez Segura et al., 2018; Vanhée et al., 2018), embodied signals in VR to support emotional communication, social affiliation, and shared navigation (Kolesnichenko et al., 2019; McVeigh-Schultz et al., 2019), and new geometries of attention for large group interactions (McVeigh-Schultz & Isbister, 2021; McVeigh-Schultz et al., 2019).

Gibson's concept of 'affordance' models perception in terms of action capacities of the physical world for an embodied subject (Gibson, 1979). Social affordances represent an alternative ecological approach to social interaction (Gaver, 1996), whereby the interactive features of bodies, artifacts, and environments all become potential resources for social mediation and coordination – a framing that echoes Hutchins's work on distributed cognition (Hutchins, 1995). In the physical world, for example, we can conceive of the social affordances of whiteboards, projectors, microphones, name tags, sticky notes, and other props that can be passed from hand to hand. These sorts of mediating artifacts can transform the ways that humans think and interact with one another, enabling new kinds of social coordination to emerge. Similarly, HCI has long demonstrated the role that technological mediation can play in augmenting perception, memory, and sense-making (Schmidt, 2017) and, in particular, underscored the important role that social forms of distributed cognition can play in supporting new capacities of human coordination (Hollan et al., 2000; Rogers & Ellis, 1994). Aligning with this approach, we envision a role for social augmentations in VR meetings that treats *shared social experience itself* as the site of design intervention (as opposed to intervening at the level of the individual perception). This is a perceptual shift that we believe can lead to fruitful reconception of technological support for interpersonal communication and connection (Isbister, 2019; McVeigh-Schultz & Isbister, 2021). Our approach to designing for meetings in VR, then, is to provide multiple participants with novel embodied capacities, social artifacts, and environmental features in order to unleash new collective human capacities and establish new grounds for effective collaboration and social connection. We contend that, by augmenting social processes and social signaling, designers can unlock new social superpowers in VR. This approach builds upon trends we have observed through analysis of current social VR practice in commercial and artistic spaces (Kolesnichenko et al., 2019; McVeigh-Schultz et al., 2019; McVeigh-Schultz, McVeigh-Schultz, Márquez Segura et al., 2018), and we synthesize some of that research below.

3. Emerging opportunities and lessons from current social VR

Existing commercially available VR meeting applications include: Spatial, MeetinVR, GlueVR, Mozilla Hubs, VRChat, AltspaceVR, and Rec Room. In particular, the makers of work-oriented applications like GlueVR, MeetinVR, Spatial, and Facebook Horizon Workrooms seem eager to replicate familiar interactions from meeting environments in the physical world. The implicit assumption that VR meetings should be modeled on "real life" is reinforced by the near ubiquity of features like virtual whiteboards (Figure 1), virtual sticky notes (Figure 2), "projection" spaces (Figure 3), and meeting rooms that resemble familiar workplace environments (Figures 2 and 3). Facebook's Horizon Workrooms (Figure 4) application combines similar features with a hand-

Figure 1. Whiteboard featured in GlueVR.

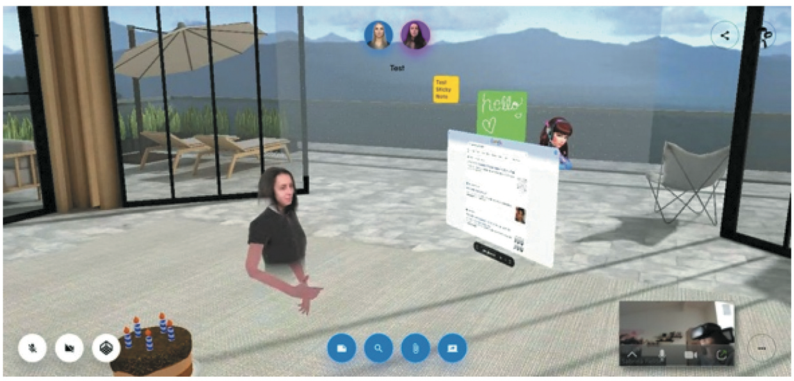

Figure 2. Participants in Spatial using sticky note and browser features.

tracking mechanic to enable controller-free gesturing and access to a physical keyboard. The architecture of these sorts of environments is also decidedly familiar and includes features like: oblong boardrooms with mahogany seats, scrum-oriented rooms with wall-to-wall whiteboards, glass "fishbowl" breakout rooms, etc., and open verandas or lounges for more casual interaction.

While such familiar features may be necessary to ease people into a new opportunity through skeuomorphic interface design, we argue that the drive to approximate the experiential tropes of meetings in physical spaces (to make VR meetings "more realistic") reflects a blindness to just how productively defamiliarizing social interaction in VR may become as we learn to adapt to and take full advantage of the affordances of the medium. Along these lines, our research has embraced "weird social" in VR and XR – alternative forms of sociality and embodiment that take inspiration from emerging practices and affordances in commercial social VR. We see this opportunity not just as a form of playfulness of expression, but as a migration toward tools that enable us to be together better – to augment the space between us to enhance our collective capabilities, creating 'social superpowers' for the benefit of us all.

Figure 3. Office environment in MeetInVR, shows “screens” where digital assets can be shared.

Figure 4. Facebook’s Horizon Workrooms featuring integration of physical keyboards and hand tracking. Reprinted from “Introducing Horizon Workrooms: Remote Collaboration Reimagined” bythe Facebook Newsroom press kit, accessed 10/20/21 https://about.fb.com/news/2021/08/introducing-horizon-workrooms-remote-collaboration-reimagined/ (Facebook, 2021).

3.1. *Leveraging metaphors of place and new geometries of space*

The approach developed here builds on insights from previous research on entertainment-oriented commercial social VR, and in particular on the ways that VR creators approach place and space (McVeigh-Schultz et al., 2019). This research drew from interviews of the creators of social VR applications including: Mozilla Hubs, High Fidelity, AltspaceVR, Rec Room, Facebook Spaces, and AnyLand. Our goal was to better understand how the creators of commercial social VR think about shaping social interaction in this quickly evolving sector. What design lessons have they incorporated? What sorts of values and approaches underlie their designs? One aspect that this research reinforced was the ways that familiar metaphors of place can activate particular registers of social participation. Or, as one developer from Rec Room put it, “rooms *are* behavior.” This sensitivity to the designed environment as a resource and arena for cultural practice echoes well-established theoretical discussions within HCI (Harrison & Dourish, 1996).

In other cases, however, the affordances that VR creators build into their environments go far beyond the familiar, supporting new kinds of social affordances not possible in physical space. This sort of departure from the known was particularly salient in contexts where creators had to design environments and feature-sets for large public gatherings where many participants needed to coordinate communication among each other.

What follows is a brief but illustrative example focused on the evolution of a social VR Q&A environment (Figure 5). (This scenario was referenced in a more cursory form in previous work (McVeigh-Schultz et al., 2019), but here we elaborate on the context with an eye toward unpacking the relationship to social affordances.) During interviews, the creators of both AltspaceVR and Rec Room discussed participating in regular Q&A events or “town hall” gatherings as a way of communicating with and getting feedback from their users. The application creators and community coordinators developed innovative approaches to environmental design and communication affordances. Rec Room developers and community managers stressed the importance of architectural layout in an auditorium room (with a stage for speakers and seats for audience members) that was designed for Q&A sessions between the player community and the Rec Room developers. Tamara Hughes, a community support coordinator for Rec Room, noted that earlier iterations of this space lacked seating and levels and that it was a “mad house because people would just [stand] at the front.” As a result, the development team added seating, to make it feel more like a odelle space, which encouraged users to sit down and be quiet. They also enabled the couches to be teleport targets, which would position one’s avatar in a seated position. Finally, they added privileged roles for speakers on the stage vs. in the audience. Those in the audience, however, could speak audibly if they were handed a microphone.

The design choices described so far are modeled on existing social expectations of an auditorium and the social ritual of audience participation, in order to support and prime expectations about appropriate behavior in a Q&A. Also note that the specific affordances Rec Room created parallel

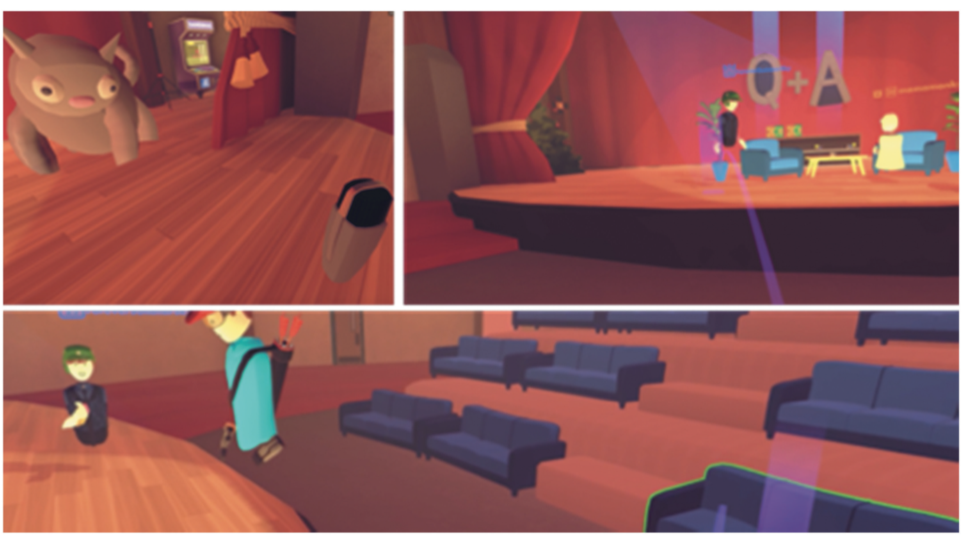

Figure 5. In Rec Room’s Q&A, audience members can teleport into seated position on couches (lower image) but are not able to teleport onto the stage unless invited (upper right). A giant cat stares at a microphone which can be handed off to an audience member (upper left).

Figure 6. In Rec Room's Q&A, this giant cat (NPC) sits on the stage and locks eyes with whomever currently has a microphone, so that audience members can track who is speaking at any given time.

these expectations (only certain people can get on stage and only participants with a mic can talk), so the designers have also restricted participation to practices which conform to those expectations.

However, the creators found that it was difficult for participants to spot who in the audience was currently speaking into the mic (since signals of spatialized audio and body language are not as clear as they might be in physical space). To address this problem, the creators came up with a rather unusual solution. They designed a giant cat non-player-character (NPC) to sit on the stage to the side of the speakers and look at wherever the mic was at any given time (Figure 6). With giant pupils visible to those in the audience, this NPC stares in the direction of the microphone-wielding participant, so other attendees can track who is speaking at any given time. The introduction of this element into an otherwise familiar context opened up new capacities of social coordination and new geometries of attention (i.e. new configurations of eyelines as participants monitor the cat's gaze and recursively attend to its attention).

This example is illustrative of a common pattern we see playing out in the play-based social VR sector – creators begin with familiar scaffolding, but then introduce new social affordances that begin to augment and stretch our expectations about space,communication, and social interaction. We hypothesize similar processes of discovery could uncover new social affordances in workplace VR meetings that expand our understanding of communication beyond what is possible or familiar in physical space.

3.2. *Embodied signaling to support trust and connection*

Our research on social VR also suggests that embodied forms of emotional signaling and affinity signaling can support rich opportunities for building trust and connection (Kolesnichenko et al., 2019; McVeigh-Schultz et al., 2019). Emojis in VR offer an alternative channel for users to communicate affect, especially in group situations when attention may be split between a speaker or performer and an emoting audience. Figure 7, Figure 8 depicts emoji signaling in AltspaceVR, one of the software applications we examined in this work. These signals emanate from a user's body and float upwards. During a highly touted first live concert by Reggie Watts in AltspaceVR, audiences utilized this emoji system as a way of communicating collective ambient feedback en masse (for example, as a form of visual applause, laughter, or appreciation).

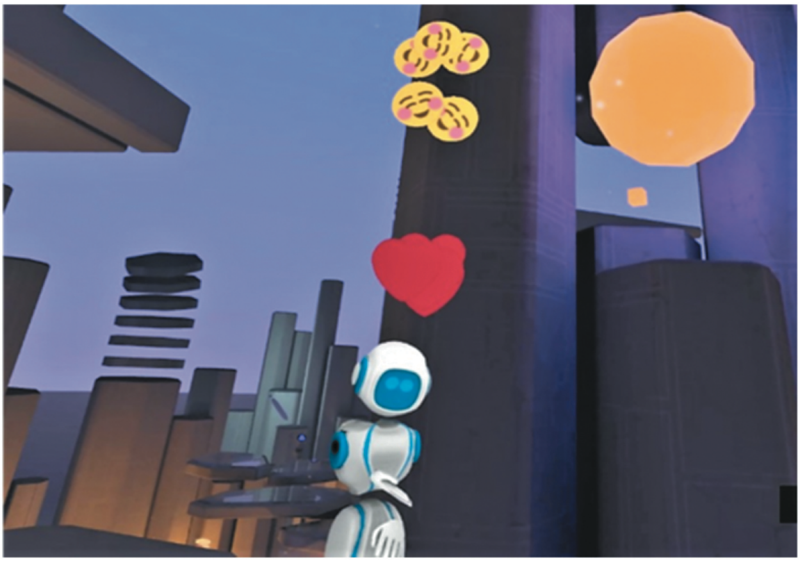

Figure 7. Emoji signaling system in AltspaceVR.

Figure 8. An audience in AltspaceVR signaling with emojis during Reggie Watts's performance. Image reprinted from Direhawk's Den by Hawk's Nest https://www.youtube.com/watch?v=qaAnAt8rAng, Creative Commons Copyright Attribution license 2017.

In Rec Room, the 'Expresso' emoting system (Figure 9) represents a different emoji mechanic that enables users to quickly gesture to select a facial expression, which then appears as a bubble above their avatar's head.

In addition, in Rec Room users not only signal emotions, but also team affinity, as a way of managing how groups navigate. The colored watch bands in Figure 10 let team members know that they can travel to a new world together as a unit, and they also signal a shared identity within a team.

We hypothesize that similar opportunities to communicate affect and affinity could be utilized in workplace meetings in VR. That said, despite the introduction of emotion and affinity signals in a variety of VR platforms, significant design questions remain regarding the best way to support

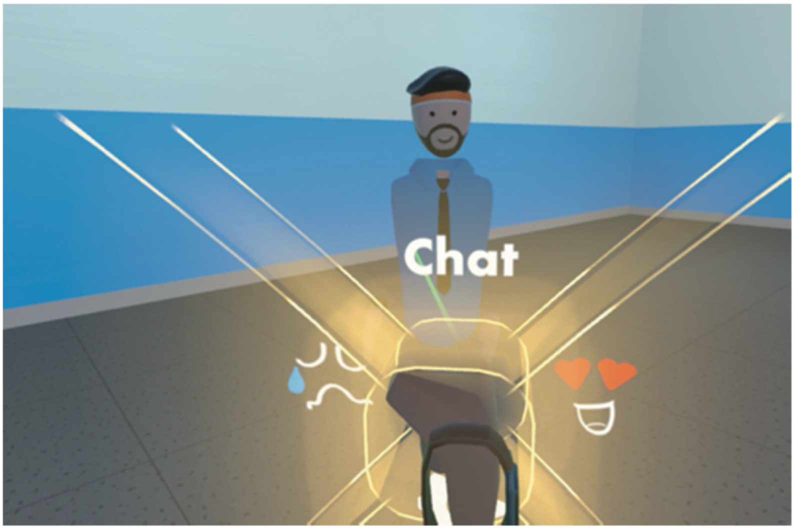

Figure 9. ‘Expresso’ emoting system in Rec Room.

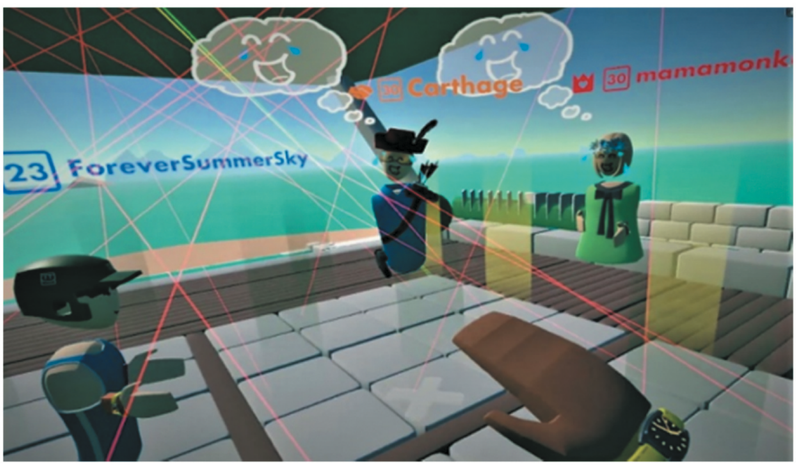

Figure 10. ‘Expresso’ emoting system and team bands in Rec Room.

communication goals of groups. Are traditional 2D emoticons that float upwards and then disappear indeed the best way for collections of users to communicate affect? Should shared affinity signals be enduring cues (as in the Rec Room example), or could they also serve as ephemeral signals of affinity toward others that ebb and flow with context? We contend that commercial explorations of these sorts of design opportunities are only scratching the surface. Significant design questions remain about how such social signals should be represented in the VR environment to best help participants make sense of social dynamics over time. This discussion can also be enriched by well-established HCI research on sociometric feedback and (2D) visualization systems (a topic to be discussed further below).

4. Social super powers in VR: A case study of immersive designs for conversational parity

In the previous section, we outlined lessons learned from surveying the state-of-the-art in social VR environments. Here, we briefly describe an example of our Research-through-Design (Zimmerman et al., 2007) approach to building prototypes that explore shared social 'superpowers' in social VR meetings. Research-through-Design (RtD) is the generation of new HCI knowledge through the process of design ideation, iteration, and development of prototypes that explore possible and desirable future directions for technology. Our research team is engaged in an ongoing RtD process focused on meeting support in social VR. We leverage existing social VR platforms such as those discussed above, as well as our own prototyping environment (using the Unity game engine), to mock up and iterate ideas for where social VR may go, and what sorts of social superpowers may be most beneficial in supporting connection and collaboration in virtual meetings. We draw upon relevant literature to guide our brainstorms and prototypes, and to help us set up appropriate evaluative criteria for assessing whether and how these prototypes function for end users.

This work can be seen as part of a larger set of concerns in HCI around sociometric feedback and visualization. Our first prototypes have been focused on supporting conversational parity (balance among participants). Research has demonstrated that parity in meetings can be a particularly valuable goal for supporting effective teams, since group problem-solving capacity is largely driven by interaction dynamics, and more balanced turn-taking is predictive of better performance (Woolley et al., 2010). This notion echoes other research that shows more inclusive member participation supports group performance (Paulus & Nijstad, 2003). While parity is just one among a number of possible values to support in workplace meetings, we have started with this as a design goal in part because it has represented such a salient target for interventions in a range of research contexts (detailed below). Moreover, the concept of parity in meetings has served as an interdisciplinary nexus for research from psychology, organizational management, and HCI.

4.1. *Related work on sociometric feedback and visualization*

Existing HCI research on (non-VR) social augmentation for meetings has explored a range of data visualization feedback mechanisms. These include a wide range of technological interventions that visualize social processes in order to improve the social dynamics of meetings, for example, by reducing interruptions and supporting conversational balance (T. Dagan et al., 2018; DiMicco et al., 2007, 2004; Kim et al., 2008; Kulyk et al., 2006; Leshed et al., 2007, 2009; Pentland et al., 2012; Tennent & Jung, 2019). Related meeting augmentation interventions include anonymous voting feedback (Bergstrom & Karahalios, Bergstrom and Karahalios, 2007b), agent-based moderation systems (Barthelmess & Ellis, 2002a; C. Ellis et al., 2003; 2003; Isbister et al., 2000; Kuperus, 2006; Tennent & Jung, 2019), AI-driven social inference systems (Barthelmess & Ellis, 2002b; J. Kim & Shah, 2016; Tausczik & Pennebaker, 2013), robotic agents (Tennent & Jung, 2019), and augmented or "smart" meeting environments (Freitas et al., 2015; Lahlou, 2009; Rienks, 2007). Many of these augmentations serve a dual purpose of influencing social dynamics in the moment while also supporting social sensemaking over time. Other research has explored distorting these sorts of feedback signals (for example, making people appear more talkative and dominating) in order to demonstrate the influence such systems can have on social behavior (Bergstrom & Karahalios, 2012).

Of this work, research on meeting augmentations for interactional parity has a particular well-established track record and rationale. Research has shown that greater parity of conversational turn taking is predictive of group performance (Woolley et al., 2010). Moreover, balanced engagement is particularly important for facilitating creativity in meetings (Kocsis et al., 2015). Within HCI, interactional parity has been explored through a range of visualization and feedback systems, including portable devices that detect and communicate social signals (T. Kim et al., 2008), real time sociometric data visualization (DiMicco et al., 2007, 2004; Kulyk et al., 2006; Leshed et al., 2010, 2007, 2009), chronological displays (Bergstrom & Karahalios, Bergstrom and Karahalios, 2007a), ambient light displays (Occhialini et al., 2011), robotic agents that intervene during meetings by signaling disparities in interactional parity (Tennent & Jung, 2019), and our own design research on wearable parity visualizers (Dagan et al., 2018). An early example of this kind of study of real-time feedback to increase social awareness by DiMicco et al. is depicted in Figure 11 and used projection of simple bar graphs to convey relative participation.

Later, research by Taemie Kim, Sandy Pentland, and others explored new mechanics of sociometric tracking and feedback through mobile mediator devices (T. Kim et al., 2008). Projects by

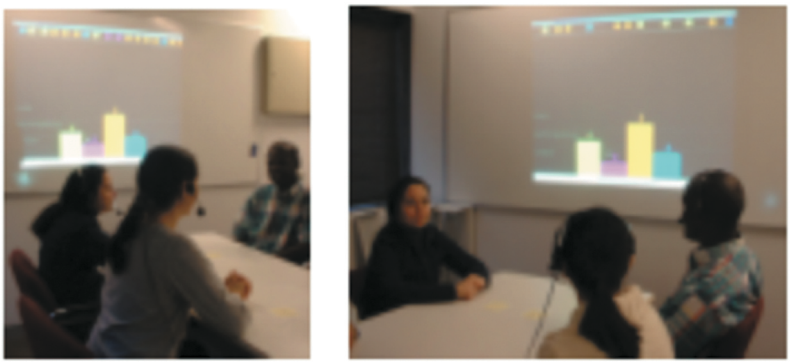

Figure 11. Social feedback visualization (DiMicco et al., 2007). Reprinted from "The Impact of Increased Awareness While Face-to-Face" by DiMicco, J.M., Hollenbach, K.J., Pandolfo, A. and Bender, W. 2007. Human–Computer Interaction 22, 1–2: 47–96. Copyright by Joan DiMicco 2007. Reprinted with permission.

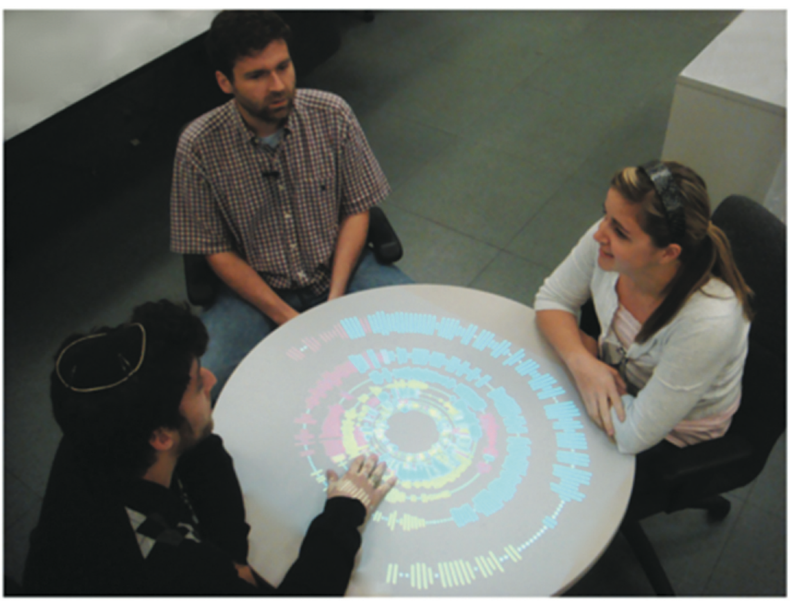

Figure 12. Conversation Clock social feedback display, reprinted from "Distorting Social Feedback in Visualizations of Conversation" by Tony Bergstrom and Karrie Karahalios, 2012, 45th Hawaii International Conference on System Sciences, IEEE, 533–542. Copyright by Tony Bergstrom and Karrie Karahalios 2012. Reprinted with permission.

Figure 13. Wearables that help manage balanced participation in a conversation. From Dagan, E., Márquez Segura, E., Flores, M., and Isbister, K. 2018. 'Not too Much, Not too Little': Wearables for Group Discussions. *Proceedings of CHI EA*.533–542.

Figure 14. Interactive microphone intervenes to prompt meeting participants. Reprinted from "Micbot: A Peripheral Robotic Object to Shape Conversational Dynamics and Team Performance" by Hamish Tennent and Malte Jung, 2019, ACM/IEEE International Conference on Human-Robot Interaction, 533–542. Copyright by Hamish Tennent and Malte Jung 2012. Reprinted with permission.

Tony Bergstrom and Karrie Karahalios explored conversation visualization through a "conversation clock," a circular chronological visualizer that was mapped onto a circular table surface Figure 12.

Researchers in this area have also explored more nuanced metaphors for social visualization such as schools of colored fish swimming (to convey social dynamics), as in Leshed et al.'s Group Meter projects (Leshed et al., 2010). Other research has also explored more customized devices such as wearables for conversation balance, as in a project by Dagan et al. (2018) (Figure 13).

Finally, more recent work as explored non-humanoid robotic agents that intervene during meetings by subtly signaling disparities in participation through shifts in orientation (Tennent & Jung, 2019), for example, a robotic microphone that "points" to a participant who has not spoken for a while (Figure 14).

It should be noted that much of this existing work situates feedback mechanisms as ambient elements of an environment, rather than embodied or volumetrically spatialized aspect of an environment (with the notable exceptions of wearable visualizers (Dagan et al., 2018), robotic agents

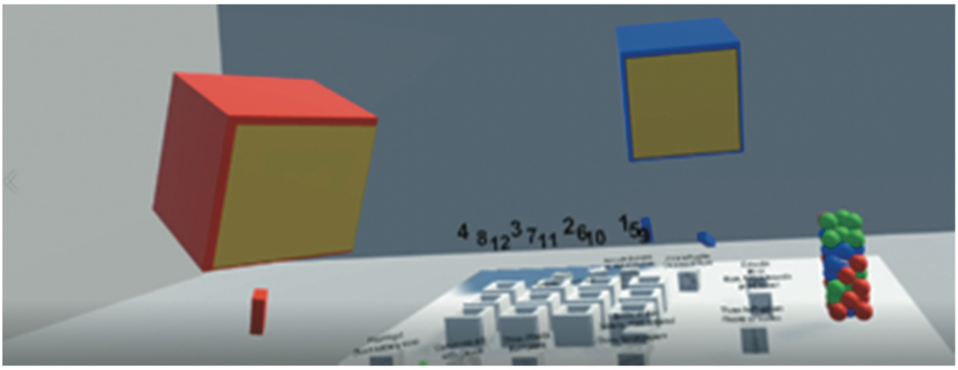

Figure 15. Simple geometric avatars at a shared table, working on the desert survival problem using a shared tray of the objects. In this figure, we see the abstract data visualization intervention. Reprinted from *Supporting Collaboration in Social VR*, by Sean Fernandes, 2020, MA Thesis for Computational Media, UC Santa Cruz. Copyright by Sean Fernandes, 2020. Reprinted with permission.

(Tennent & Jung, 2019), and ambient light displays (Occhialini et al., 2011)). Our own research on pro-social interaction in social VR, however, suggests that richer social signaling can be achieved by embedding social signals within the environment and the body (McVeigh-Schultz et al., 2019).

Along these lines, we propose that VR has particular promise as a medium of social augmentation visualization and feedback through a range of techniques and mechanics, including: (1) embodied extensions/manipulations of avatars, (2) changes in environmental ambiance, (3) accentuation of nonverbal cues such as proximity or gaze, (4) anonymous signaling, (5) moderating agents that can move between foreground and background as needed. These sorts of interface opportunities go beyond the kinds of visualization techniques possible in physical space.

4.2. *Two prototypes for supporting conversational parity in social VR*

Through a series of brainstorming and prototyping iterations, we created two alternate prototypes for supporting conversational parity in social VR. The first was an abstract data visualization of the conversation that was embedded in the shared environment, and the second was an ambient agent whose behavior reflected the conversation. Both prototypes were implemented in a simple, shared social VR meeting space that used a shared table as a gathering area and workspace, to help delimit the frame of reference and eliminate complexities of point of view and navigation. We created very simple, abstract avatars for each conversational participant, who could be distinguished by differing color (see Figure 15).

4.2.1. *Conversation visualization in VR*

The abstract data visualization prototype drew inspiration from work of Bergstrom and Karalios, as well as unpublished prototyping work from USC in which avatars spew balls from their mouths when they talk.[2] The core concept was to provide an in-the-moment visualization of how balanced (or not) the conversation was, in order to help conversation participants to notice imbalance and to self-correct their behavior.

RtD design methodology played a crucial role in shaping the specific mechanics of this visualization. Through the process of making and experiential testing, we clarified emergent knowledge, surfaced new design questions, and ultimately generated richer ideas. Initial prototypes involved tennis-ball size spheres popping out of avatar's mouths as they spoke (following the USC example

[2]This work was developed as part of a speculative exploration by Scott Fisher's Mobile & Environmental Media Lab at the University of Southern California, part of a broader immersive design fiction research agenda (McVeigh-Schultz, Kreminski et al., 2018). For documentation of the prototype, see (McVeigh-Schultz & Isbister, 2021).

above). However, through testing and bodystorming explorations, new questions arose, such as: Where else can the balls spawn? How frequently should they spawn? What size should they be, and should size correlate with some measurable aspect of speech such as volume? Where should balls be accumulating once spawned? And how can we best give participants a sense of speech output relative to others? In response to these questions, we generated a flexible ball spawning system anchored to controllers that enabled us to modulate spawn-frequency, location, and size in real time while testing out the experiential impact of various choices.

After multiple iterations, we settled upon a transparent column visible to all conversational participants (see Figure 15). The column would fill with balls that matched each participant's avatar color. e.g., if red talked more, there would be more red balls in proportion to other colors. The final design of this prototype did not accrete the whole conversation over time, but rather, reflected a recent temporal period that continued shifting forward gradually over time.

4.2.2. *Conversation agent in VR*

The ambient agent prototype drew upon the work of Tennent and Jung with Micbot (Tennent & Jung, 2019) as well as the microphone cat in Rec Room. In this example, there is another avatar in the room not piloted by a participant, but rather, by the system itself – an NPC (non-player character) – that aims to shape the parity of the conversation. As in the ball-spawning example, the prototyping process for the NPC agent example followed an RtD approach. We generated a "sandbox" of doll-scale assets to represent avatars and possible NPC-agents in a social VR environment. Through in-VR multi-user brainstorm sessions (Figure 16) we manipulated these assets to better understand aspects of body orientation and eyeline. Questions included: how would the NPC behave when someone was talking too much? Would it move toward that person, stay behind them, or stand in front? How would it behave when someone new starts talking – would it turn to that person, move toward them, or just look at them? By representing the participants and NPC as miniature tokens ("dolls") we were able to facilitate a much richer discussion and generate more thoughtful ideas.

In the final iteration, an NPC was designed to look similar to the other avatars and would turn its "gaze" toward whomever was currently speaking. Over time, it would be attracted to the dominant speaker, and it would shift color to match that person's avatar. The NPC would also approach that person's avatar, looming in their peripheral vision, and providing a not-so-subtle cue that they were taking the focus of everyone.

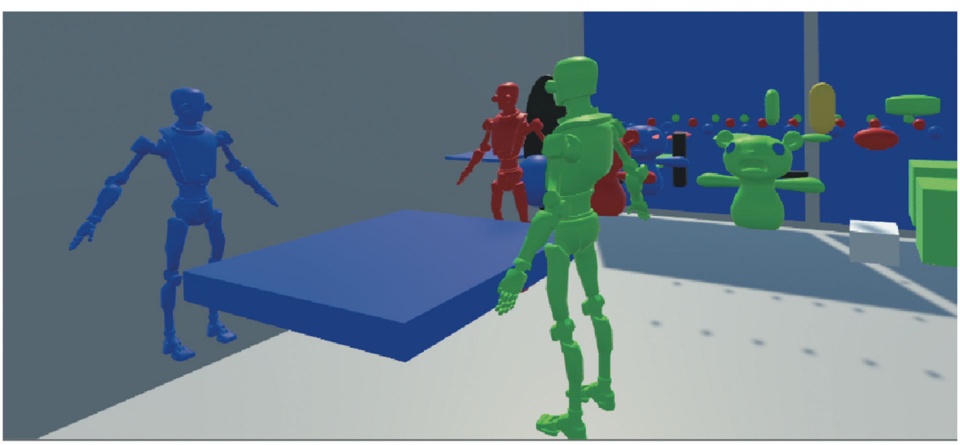

Figure 16. Bodystorming environment with placeholder avatars, NPC agents, and balls to represent data visualization elements. Reprinted from *Supporting Collaboration in Social VR*, by Sean Fernandes, 2020, MA Thesis for Computational Media, UC Santa Cruz. Copyright by Sean Fernandes, 2020. Reprinted with permission.

4.2.3. *Experimental validation*

Preliminary results of testing these two prototypes are elaborated elsewhere (Fernandes, 2020), but here we briefly describe our strategy for conducting such evaluations. We believe it is important to ground our RtD design innovation with evaluative strategies that circle back to measuring whether and how meetings are better supported. In the case of conversational parity, we devised a set of measures that could give us a rich picture of how the prototypes did (or did not) support the conversation. Behaviorally, we tracked actual parity – how balanced was participation in the conversation, as measured by time talking? We also asked participants how balanced they thought the conversation was. Attitudinally, we asked participants how effective and enjoyable the meeting was, and how close they felt to other participants (using the Inclusion of Other in the Self scale (Aron et al., 1992)).

Finally, we situated the use of the prototype in a well-understood laboratory task – the desert survival problem – used by Tennent and Jung (2019) and many other researchers. In this task, participants are told they have crashed in the desert, and have a set of items that survived the crash. They are asked to rank the items in terms of survival value. Participants first rank the items on their own, then have a discussion, and then produce a final set of shared rankings. We can look at how much rankings changed as an indicator of the quality of the conversation, and we can also look at how close the final rankings are to optimal rankings. In our prototype environment, we created a tray with blocks that represented each item (see Figure 15). Participants could move the items into different positions in the tray, to show how they would rank them, allowing for group manipulation toward a shared set of final rankings.

Overall, the case study above illustrates an exemplar of our RtD approach to building possible futures for social VR. We select finer-grained research problems/opportunities (such as conversational parity) and build multiple candidate prototypes to support these meeting processes. After iterating and testing them internally, we devise lab-based evaluative studies that help to validate whether and how the prototypes are supporting these processes. Ultimately, we aim to have a set of validated prototypes of social superpowers that showcase the possible future that we envision for social VR as a meeting support environment.

5. Reflections and questions

Through the case study above, we can start to understand the ways that novel augmentations in VR can serve as shared social resources. Laboratory participants were able to rely on the VR environment as a resource for shared thinking. At a basic level, when participants collaboratively move the desert survival items around within the ranking tray, they are externalizing their thinking and communicating to the group through the environment itself. Likewise, in the experimental contexts, the accumulation of colored balls and hovering bots served as a shared resource for social sense-making, one that offloaded the job of signaling under- or over-participation relative to the group. In this case, what is being externalized is an implicit social dynamic rather than explicit rhetorical position about item ranking. By externalizing these sorts of implicit dynamics, the environment itself can shape or scaffold social interaction in ways that go beyond what is typically possible in physical meeting contexts. (In the physical world, we don't spawn balls or leave traces in the environment when we talk and we don't have hovering bots intervene when we have been talking too long.) These novel social augmentations echo ecological approaches to social interaction (Gaver, 1996; Hutchins, 1995) where aspects of the environment reflect, externalize, and influence social processes in dynamic ways.

Novel social augmentations in VR could potentially scaffold a wide range of social phenomena, including the collective communication competencies (CCC) that are the hallmark of effective meetings (Thompson, 2009). The CCC framework conceptualizes communication in meetings as a *collective* capacity that exists in the space between people (meeting participants are more than the sum of their parts). This framework has become critical for our RtD work in this area, helping us to stay grounded by real-world meeting contexts as we explore novel affordances in VR. Key collective competencies include: practicing of trust, balancing task-related talk with relational talk, and reflexive awareness of communication. With the CCC framework in mind, we theorize that novel social augmentations in VR could help meeting participants to improve their collective competencies by: nurturing social connection and affiliation, sticking to an agenda, managing time, coming to decisions effectively, and balancing participation.

We are continuing to engage in a Research-through-Design process to build multiple exemplars of social affordances in VR (in support of CCC), testing them against meeting spaces without such affordances. A range of possible techniques we are exploring in this space includes: (1) building trust and rapport through embodied forms of affinity signaling; (2) managing time and emotional tone through dynamic ambiance mechanics; and (3) supporting awareness of social dynamics (both verbal and non-verbal) through volumetric visualizations, animations, and NPC agents that respond in real time to sociometric data.

Here are some of the questions that continue to guide this work:

- Which sorts of social affordances are most beneficial, and how should they operate to support particular social practices?
- In what contexts should social feedback be driven by environmental cues vs. embodied signals vs. NPC agents vs. some other novel mechanic?
- When should social augmentations in VR be scaffolded by familiar real-world analogues, and when should we instead break new ground by exploring unfamiliar social affordances and mechanics?

Exploring these questions, our RtD research has drawn inspiration from meeting augmentation research in HCI as well as from emerging design insights and practices in play-based commercial social VR.

HCI research on socially augmented meetings in physical contexts has demonstrated the benefit of ambient social feedback through dynamic visualizations in a range of forms. To elaborate on related research described earlier, specific visualization feedback strategies include representing social processes: as animated agents (Leshed et al., 2010, 2009), as chronological traces (Bergstrom & Karahalios, Bergstrom and Karahalios, 2007a), as ambient displays (Occhialini et al., 2011), or as monitors that alert participants when certain thresholds have been crossed (Dagan et al., 2018; Tennent & Jung, 2019). Likewise, NPCs can serve as meeting moderators, gracefully intervening at key moments to help shape meeting dynamics through, for example, conflict mediation (Shen et al., 2018) or as meeting moderators that assist with tasks like time management (C. Ellis et al., 2003; C. (Skip) Ellis et al., 2003).

Despite lessons learned from these non-VR analogues, question remain, though, about what is lost and what might be gained when comparing physical or screen-based examples to experiences of augmented meetings in VR. The affordances of immersive media suggest a different set of possible cues (for instance, novel modes of embodied signaling), different ways of managing attention, and different approaches to supporting social feedback and sense-making through immersive features.

Lessons from design insights and emergent practices in play-based social VR also suggest new ways of approaching social augmentation mechanics. Drawing inspiration from these examples, we have shown how virtual meeting experiences can prime social expectations through skeuomorphic cues and esthetics of place, but they can also create novel affordances that enable new social configuration and practices. Such novel mechanics – like the giant NPC cat in Rec Room or the embodied signaling in a range of platforms – point to significant differences between how social augmentations operate in physical space vs. immersive virtual contexts.

Questions remain, however, about when to rely on skeuomorphic analogues from the physical world to scaffold experience. Or alternatively, in what sorts of contexts is it more advantageous to explore novel mechanics that depart from familiar analogues and instead activate new practices of communication and coordination? Finally, if the two approaches are combined (as they are in the

Rec Room Q&A environment example), are there best practices for integrating these different approaches?

6. Conclusion

With COVID-19 having accelerated broad shifts to remote work, workers are continuing to adapt to affordances of video conferencing and developing new social practices and literacies along the way. In some cases, such practices are likely shaped by particular interface features (such as screen sharing, breakout rooms, reaction icons, etc.), and in other cases, emergent practices may push against the grain of interface options (for example, when Zoom participants collectively agree to remap the meaning of reaction icons to some other purpose on the fly). Alongside the rapidly evolving media literacies of remote workers, we anticipate an increasing sophistication of, and demand for, alternative platforms for remote work. In a future where VR can reliably convey facial expressions and integrate peripherals, we anticipate greater adoption by remote workers, especially in contexts where richly embodied aspects of co-presence are beneficial. By supporting richly embodied forms of co-presence, VR meeting tools also carry promise for remote workers to continue to connect across the globe while reducing the carbon footprint associated with travel.

Helping to flesh out the contours of this future, emergent features and social practices in commercial social VR point the way toward new forms of social augmentation that take advantage of the unique media properties of shared immersive spaces. Likewise, academic researchers in HCI continue to innovate new strategies for supporting mutual attention, connection, collaboration, and trust building that we can learn from in designing work-focused tools and platforms in VR.

It is our belief that social augmentation in VR, and in particular, social affordances and 'super-powers' as we have defined them here, represent a powerful potential future for workplace support of meetings. Technology is at its best when it scaffolds us in ways that supplement and even transcend what we can do in physical reality. Accordingly, we envision situations in which even co-present workers may sometimes *prefer* to meet in social VR because they appreciate the embedded social affordances that modulate team dynamics and mood, help to build trust and cohesion, and shift social processes for mutual benefit. This vision of richly embodied and spatialized social augmentation points to a "beyond being there" for effective meetings in VR.

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