PHYSICALITY MATTERS

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1. ABSTRACT

Geographically distributed design and engineering teams face barriers to effective and intuitive collaboration that current communication technologies have difficulty mediating. Contextual clues, rapid iteration of ideas and ease of direct physical interaction are often lost. We believe that introducing expressive robotic avatars into designers' workflows can create more direct, engaging and productive exchanges for geographically distributed teams.

2. INTRODUCTION

In 2000, Gary and Judith Olson stated that *distance matters* for synchronous, distant interactions. [1] The Olsons recount several characteristics laid out by Clark and Brennan [2]—including co-presence and visibility, among others—that contribute to attaining common ground among participants, but which are only partially present in communication technologies such as videoconferencing or online chat.

We agree heartily with the Olsons about the importance of common ground. Moreover, in considering the challenges facing collaborating designers and engineers, we believe, more specifically, that *physicality matters*; that the physical presence, embodiment and motion afforded to participants in face-to-face interactions enables them to establish and maintain the common ground that is critical to free-flowing, creative exchanges. Hence, the investigation of how physical factors affect distant design collaboration, and the application of this understanding to the design of telepresence systems, is key to supporting productive joint action in an increasingly distributed and globalized corporate design environment.

In our research, we are looking at how the introduction of robotic technologies can bridge—but also complicate—telepresent communications between distributed design teams. We have taken the design research approach of employing a variety of technology probes, [3] as a conduit to understanding the design issues surrounding physical telepresence, and as a way of creating research tools with which to understand how people interact with physical telepresence systems.

3. DISTRIBUTION TOPOLOGIES

An important factor in the design of physical telepresence systems is how collaborators are distributed from one another. Much of our recent experience is with design teams composed of a single collocated subgroup that is joined by several globally distributed members. Each of these distant participants is a single individual at a distinct location. This presents a *satellite* communication setup, which may include direct back-channel connections among distant participants as well, as shown in Figure 1. We call this mode of communication *1-to-1-to-many*, extending the 3 variables that Nass and Mason [4] used to analyze the organizational use of communication technology.

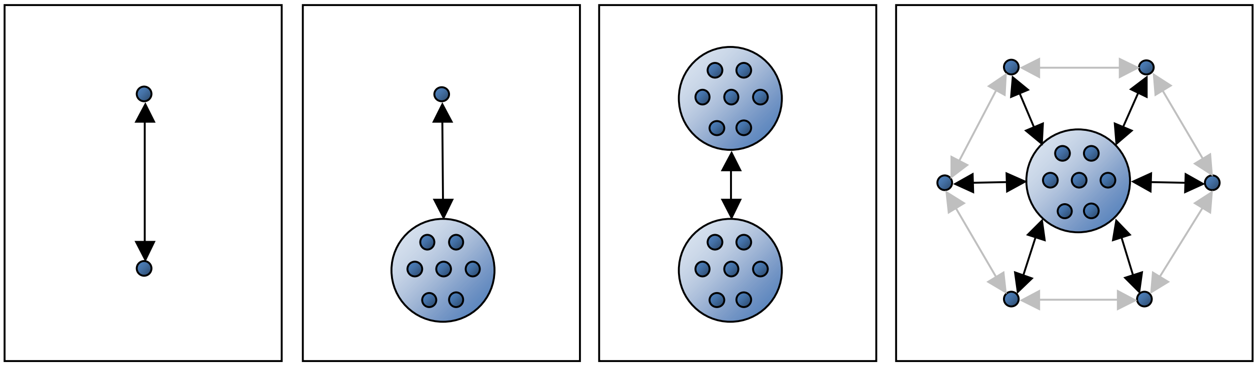

Figure 1. The left 3 modes of communication shown are 1-to-1, 1-to-many and many-to-many. In each case, there is a single channel between the individuals or groups at each end of the connection. The mode of communication on the right is what we term 1-to-1-to-many. There is a separate channel for each individual to connect to the group, as well as a back-channel to connect to other individuals.

4. ROBOTIC AVATARS

PC or laptop video chat is well suited to 1-to-1 interactions, and commercial high-definition video conference rooms are well suited to many-to-many teams, but neither suits the scale, participant orientation or physical interaction that the other forms of distributed design teams require. In these cases, video conferencing often forces distant participants to the fringes of activity by reducing their representation to a few square inches on a shared display, diminishing their expressions and gestures, and making it difficult for them to direct the attention of others. To address these particular needs, we have begun to employ physically embodied, gesturing robotic avatars at the local hub of design activity, which distant collaborators 'inhabit' during their interactions. One can consider robotic avatars as combining personal robotics with video conferencing, but they maintain two distinctions: (a) they are aids to support *communication*, rather than *manipulation*, and (b) they are devices that humans communicate *through*, rather than *with*.

Other researchers and companies are developing telepresence robots, from Hiroshi Ishiguro's Geminoid, to Anybots' QA and QB, to iRobot's ConnectR. Our approach of rapid iteration over particular communication issues differs in that we have little invested in specific design decisions, and hence are better able to map out the interaction space, and to discover what works well, what does not, and what is surprising.

5. ISSUES OF PHYSICALITY

The physicality of robotic avatars raises a number of issues not present in more traditional means of communication, including reinforcing versus undermining gestures, control, inhabitation and safety.

Our current study explores how combining a robotic avatar's physical gestures with a distant collaborator's visible actions influences the clarity and expressivity of the intended communication. The first experiment—the responses to which we are in the process of decoding—explores gestures that one might experience during a typical conversation: laughing, looking to the side or down, showing surprise, thinking for a beat, leaning in for a closer look, agreeing with a nod. We expect that certain physical gestures will map to certain visible actions to reinforce each other (as in Figure 2), and that the correspondence may not necessarily be 1-to-1. We further expect that other mappings may be equivalently effective, or alternatively, confusing to the viewer.

Figure 2. In this sequence, showing video of a cohort distant collaborator on a puppeted iMac G4, the cohort leans in toward the camera and looks into the local space, while the screen moves forward and down. Both actions occur in concert.

We are beginning to explore how inputs should be matched to outputs—that is, when it is important to use direct mappings, and when it is important to use indirect ones. For instance, in many Indian cultures, it is customary to shake one's head from side to side to indicate agreement, but in the US, this gesture is interpreted as disagreement. The avatar might perform the task of cultural translation, perhaps converting one participant's head shakes on one side of the communication to robotic nods on the other. We expect that such actions will not only affect the avatar's communicative function, but also its perceived sociability [5].

Figure 3. On the left is a robotic avatar during a design meeting; on the right is a closer view of its remote-control arm. This version's screen required a puppeteer for motion, but it has since been upgraded to fully robotic control.

On the control side, we expect to test when explicit versus implicit actions work best. For instance, it may be desirable at some times for an avatar to respond to the collaborators' deliberate commands, so as to better convey his or her intent. At other moments, it may be better to have the avatar automatically respond based on more implicit commands, [6] so as to minimize the cognitive load of use. Our evolving designs will allow exploration of the issues of usability, agency, and level of detail in the avatar's control. In this way, we plan to balance the opportunities for greater creativity against those of sensory overload.

Our next series of studies will include field deployment with working design teams. The avatar's platform (see Figure 3) makes it possible to control independent factors such as proximity, gaze, addressability, tangibility, mobility and back-channel communication to see how they affect the attitudes and behaviors of participants. In specific, we anticipate that embodiment will have strong effects on collaboration performance metrics such as joint activity, creativity and task completion, as well as on attitudinal measures of affect, trust and unity among collaborators. We hypothesize that these aspects of embodied motion and action have the potential to both distort and magnify the media effects [7] of traditional information technologies.

6. CONCLUSION

Robotic avatars may be able not only to recreate the benefits of collocated design, such as common ground or physical interaction, but to improve upon them, [8] by addressing needs that may not be met even by face-to-face communication, such as unambiguous gestural feedback, location-independent recording of sessions or 'always there' availability.

7. REFERENCES

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