How Changing Communication Channels Affect Communication Patterns: Implications for the Design of Smart Objects

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INTRODUCTION

In the knowledge economy, a significant component of group tasks and discussions is related to creative activity, i.e. an activity "involving the use of the imagination or original ideas to create something" [8]. To accomplish creative activities, professionals are frequently expected to collaborate with each other. While face-to-face communication is perceived to be the best possible medium for collaboration because of the rich information channels open to those who participate [4, 6], circumstances often require that people work remotely. While the Internet lowers the barriers to remotely connect with others, remote collaboration tools remain an active area of research.

In this paper we distinguish tree types of remote communication based on the available channels of information:

- Audio communication (A), i.e. a telephone-style conversation where only an audio channel is used,
- A combined audio channel and "shared workspace" (AS) with the possibility of making input visible to all participants, and
- An audio channel, shared workspace and full video channel (ASV) which supports non-verbal face and body communication alongside audio and shared workspaces.

Because ASV provides the richest environment for information exchange, it appears closest to face-to-face communication. Indeed, much research in remote communication has focused on replicating, in the maximum possible fidelity, an appearance of being present to more faithfully reproduce realistic face-to-face communication [1, 5].

Our initial work in remote collaboration was motivated by a desire to understand how changing fidelity of communication channels (A vs AS vs ASV) *during a single collaborative session* affects the communication patterns of *newly formed groups* of collaborators. A reader might assume that the highest fidelity channel (i.e. ASV) should be preferred. However, in a world of smart devices, such as smartphones and tablets, and smart objects, such as shared whiteboards and desktops, there is an obvious screen-space challenge if these are the primary vehicles for collaborative work. Also, previous studies [7] and results that we present in this paper show that, in some cases, having a video channel may be disruptive and also requires significant effort from users. As well, shared workspaces, while being a powerful tool for establishing common grounding, are convenient only when one is willing to either share informal content such as notes and doodles or requires the management of explicit shared and private space [10].

A MOTIVATING SCENARIO

Imagine a knowledge worker within a large, distributed company identifying a potential remote collaborator to work with. Using basic video communication technology like Skype, the knowledge worker might contact a prospective collaborator via a video call. This initial contact might evolve into a discussion and collaborative problem solving activity. Supporting this in a typical office environment, one might use a desktop computer or tablet to initially video conference with another party. However, as work progresses, the computer screen might need to be co-opted to serve as a shared workspace. Perhaps the web camera might be co-opted to transmit awareness of rough work completed on a whiteboard. On the other hand, it is also possible that, to initially contact and collaborate with another party, the knowledge worker might simply call the other party on the phone, begin with audio, and over time migrate to sharing a workspace or other higher fidelity channels.

In either initial contact scenario (video conference first or audio only first), we feel that the exploration of how changes in type of communication affects communication patterns is an interesting are of inquiry. As collaboration evolves and the focus moves from person-to-person communication to tasks around information, can fidelity change? If fidelity does change, what changes in the communication patterns? While many researchers have investigated long-term collaborative behaviours [12,7] or consistent remote communication type [11], relatively little work seems to exist on how varying communication type affects the quality of collaboration within a collaboration session with a newly formed group.

EARLY STUDY OF CHANGING COMMUNICATION PATTERNS

To begin our analysis of changing communication patterns, we conducted a within subjects, low-fidelity study with varying communication type over the course of a single collaborative session. Our experiment was conducted in the laboratory and all sessions were conducted "on paper". Experiments were conducted with groups of 2 people, and we analyse data from five groups of participants. Participants were 22 – 33 years of age, and three groups were male-female and two were male-male groups.

To simulate remote collaboration with channels of varying fidelity (A, AS, ASV), there were two tables in the room divided with a cardboard "wall-divider". We had three experimental conditions - "closed divider" or A (Figure 1a), "partially opened divider" or AS (Figure 1b) and "fully opened divider" or ASV (Figure 1c).

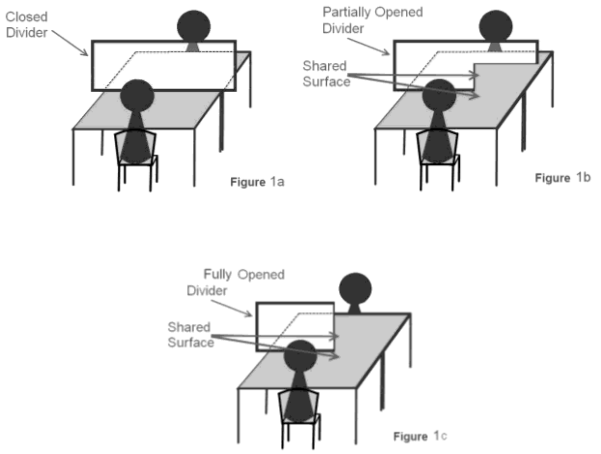

Figure 1a, 1b and 1c. Experiment setup

Participants were given two creative tasks: Task A and Task B. For Task A, participants were given information about a fictitious town, given five minutes to familiarize themselves with the town, and then told that the task was to create a tourism campaign for the town. After three minutes of individual work on the campaign, they began collaborating. For Task B, participants were asked to perform a similar task for the city in which our university is located, relying on their personal knowledge and experience with the city in question. Participants were given 20 minutes of collaboration time in each session. At the end of the collaboration time, participants separately documented the decisions that they had made together.

The experiment proceeded as follows. Participant groups were assigned to one of two conditions, "audio" first and "video" first. In the "audio" first condition, participants completed Task A with the divider closed and Task B with it partially open (10 minutes) and then fully open (10 minutes). In the "video" first condition, participants completed Task A with the divider fully open for ten minutes and then partially open for ten minutes, and the divider closed for Task B.

We recorded audio and video of the experiment. At the end of the experiment, we administered a questionnaire and conducted a semi-structured interview.

RESULTS

Several observations from our results seem particularly relevant to the design of smart devices, environments and objects, particularly as the design of these objects relates to the goal of supporting interaction between individuals collaborating on creative problem solving tasks.

Patterns of discourse

We performed an initial analysis of communication during discussion sessions. The discourse patterns can be described using three parameters, length of utterances per participant, overlapping dialog between participants, and equality of speaking time. While turn taking mechanisms [9,3] and discourse patterns [11] and impact for the relationship [2,7] of face-to-face and mediated communication have been examined, in our analysis of discourse patterns giving changing communication channels, we see the tendency of conversation patterns to be "sticky"; the conversational patterns established in the first condition (open or closed) appears to persist during the remaining conditions.

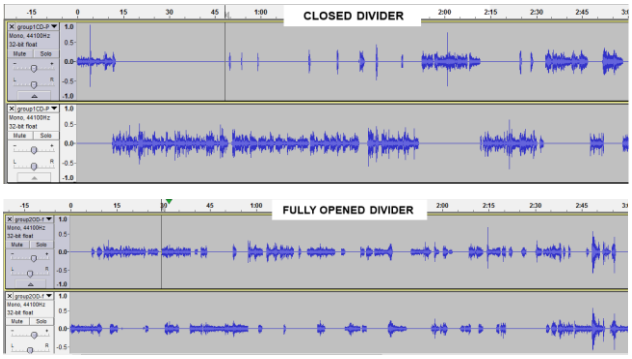

Figure 2. First condition

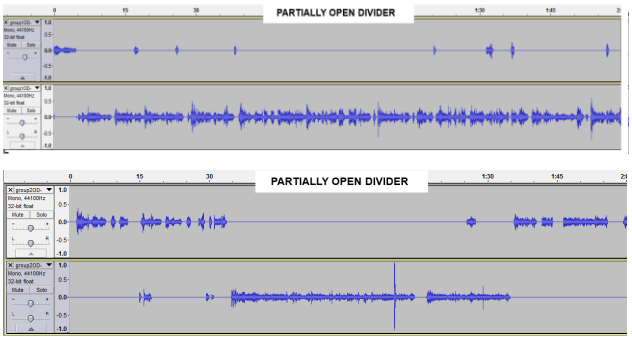

Figure 3. Second condition

Figure 4. Third condition

To see this in detail, consider Figures 2, 3 and 4, which analyse two participant groups. Participants who started

in the open divider condition (bottom panel for first, second, and last condition) tended to have shorter duration of communication with more turn-taking and more interjection of words and phrases during each other's' speaking times. Drilling down on interjections, i.e. backchannel communication, consider Figures 5 and 6 where we use primary speaker changes or long pauses to delineate a single speech instance. When participants start with the closed divider, each bar in the Figures 5 represents one speaker talking with very little backchannel communication, whereas when they start with the open divider, backchannel communication tends to be much more extensive and includes phrasal or substantive utterances (Figure 6).

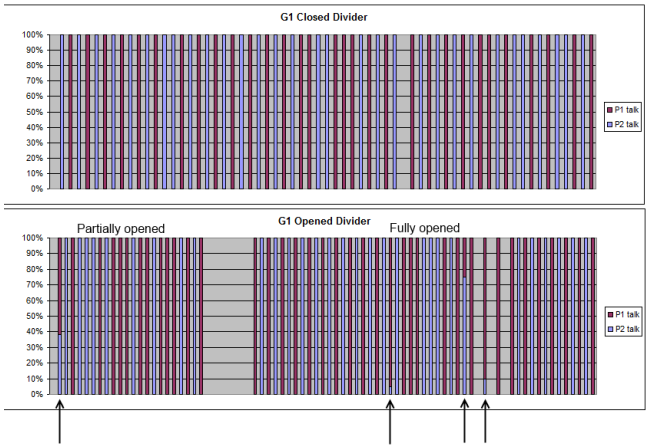

Figure 5. Overlapping speech in group started with closed divider.

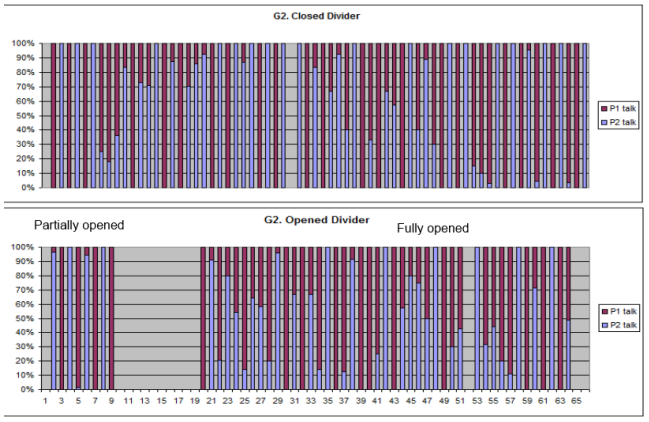

Figure 6. Overlapping speech in group started with opened divider.

Qualitative, Questionnaire and Interview Data

Our questionnaire data and interview data is primarily useful in understanding how changes in type of communication influence how participants perceive communication. While space prohibits a full presentation of these results, our early analysis provides some initial evidence for the following observations:

- *Mutual Understanding:* We analysed missing elements in post-collaboration write-ups of results and found that, after discussion with the open divider, participants seemed to have fewer mismatches in understanding. Also there is a slight tendency for those groups who started with closed divider (groups 1, 3 and 5) to have more mismatches in text even after discussion with the open divider for Task B.
- *Subjective Time:* Seven participants out of ten said that an experimental situation with an opened divider helps to reduce the time required to perform the task.
- *Sense of co-presence:* Participants, despite being seated in the same room, did identify a change in the feeling of being with the other person, including needing to speak louder, having less control over collaboration, and losing visual cues.
- *Mixed Appreciation of Video:* While most participants valued the video channel, a few noted that it can be distracting.

DISCUSSION: SMART OBJECT DESIGN

In our early results, discourse patterns seem influenced by initial communication medium, even across a single collaborative session with new collaborators. This persistence in communication patterns motivates our interest in smart, internet-connected object design.

As per past research in non-verbal communication, we believe that the interaction patterns established via visual channels enrich communication. Arguably; then, the communication patterns seeded by the initial open-divider condition promote a communication pattern that merits preservation across the collaborative session. Our observation that this initial open-divider communication pattern persists over a second, twenty minute collaborative task even with the divider closed, has two primary implications for the design of smart objects.

First, while the ideal might be to create advanced virtual presence systems, many people must make do with lower fidelity virtual presence tools and a limited amount of screen real estate in their work environment; often the extent of the tools available includes a computer with a web camera and a cell phone. However, given a set of smart objects that permit varying fidelity within the communication channels between two collaborators – from rich A/V communication down to a basic teleconference call – it may be possible to design smart objects that can preserve the video-conferencing-like communication even if these smart objects simply provide an audio channel or even just simple workspace awareness mechanism like a streamed physical desktop. As necessary, high resolution displays can be re-tasked away from video conferencing and toward accomplishing shared work tasks without altering communication in the short-term – at least according to our early observations.

Second, given a set of smart objects designed to support communication between collaborators, it may be possible to automatically perform manipulations that preserve communication patterns, particularly if the initially established patterns start to change over the course of the collaboration. Basic turn-taking and backchannel utterances could be monitored, and, when communication starts to resemble closed-divider style communication, a higher fidelity channel (e.g. more advanced shared

workspace, video conference) could co-opt some work space so that a desired conversation pattern is preserved.

Finally, another design implication which partially validates some past work is the potential benefit of non-video communication during a subset of tasks. In past work Nardi et al. [7] noted that video communication can feel unwieldy in some collaborative tasks, and our participants' comments indicate a possible replication of this result. Essentially, some participants noted that, as they moved from exploring data to ideation to solution generation the utility of the video channel changed. Smart objects can flexibly support the desired changes in communication methods.

CONCLUSION

In this abstract, we present our early work on analysing how communication changes as communication channels change during remote creative problem solving tasks for small, newly formed groups. In particular, our early data indicates persistence in communication style. If validated, this persistence can be leveraged to inform the design of smart objects that support inter-personal communication.

ACKNOWLEDGMENTS

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