To Share or Not to Share – Distributed Collaboration in Interactive Workspaces

Hillevi SUNDHOLM[1]
Dept. of Computer and Systems Sciences
Stockholm University/Royal Institute of Technology, 164 40 Kista, Sweden
E-mail: hillevi@dsv.su.se

Abstract. We followed an international research network that holds regular meetings in technology-enhanced working environments. The team is geographically distributed and uses a set of technical artefacts to support their collaborative work, including a videoconferencing system and a media space. We have been studying how mutual understanding is created between the team members and the role that visual representations play in this work. Our approach has been to analyse the initiatives and responses made by the team members. The meeting situation is complex because the team members are participating either in both video and audio, or audio only. In this multi-channel setting it often has to be clarified who is attending, and there is also a risk of team members being forgotten when they are present only on audio. The communication space is limited; when many want to participate in the communicative activity, it becomes harder to make successful initiatives; moreover, the roles of the team members seem to become accentuated in the distributed setting. The media space is restricted in that it only allows one person to be active at the time; this causes problems when several persons want to contribute simultaneously. Some of these limitations in the system are overcome through verbal articulations of actions.

Keywords: Common ground, Awareness, Distributed collaboration, Shared workspace, Interactive spaces

Introduction

For some time now, distant collaboration has been suggested as an alternative to travelling and face-to-face meetings; it is now seen increasingly often, driven partly by technological improvements and partly by globalisation. It is also a consequence of workers belonging to several teams at the same time, making it physically impossible to be co-located with all of them, all the time [36]. Although current technologies offer many different possibilities for communicating, interacting, and sharing information simultaneously at a distance, people still prefer to work at the same place using a common collaborative space [39]. It is also known that the frequency and quality of communication declines when the distance increases between participants' offices [23]. This finding has been supported recently in an experimental study [7], where the

[1]This work was conducted at EDF R&D, Laboratory of Design for Cognition (LDC), 1, avenue du Général de Gaulle, 92141 Clamart cedex, France.

authors concluded that those in the field of Computer-Supportive Cooperative Work (CSCW) need to pay more attention to the design of technology to overcome social and geographical distance.

Our work focuses on collaboration in so-called interactive spaces, and more precisely on the role of visual representations when conducting teamwork and the ways that team members come to contribute and express ideas in such environments. In previous research we studied co-located collaboration in an interactive space. We found that even peripherally-located team members can have an immense impact on the overall work and that their ideas could be captured and followed up later on even if they were given no attention during the interaction [43]. We have also reported on the role of large interactive screens for communicating, expressing, and negotiating ideas [3, 43, 44].

In this paper we present a case study with a group of researchers who regularly engage in geographically distributed meetings in interactive spaces. The team uses a set of technical artefacts to support their collaborative work, including a videoconferencing system and a media space. In this area of research many studies focus on systems and users, and on the specific design of shared tools for distributed collaboration (cf. [11, 17, 28, 38, 47]). However, we see a lack of long-term empirical studies that are aiming at furthering our understanding regarding teamwork in these settings. Our particular interest is how team members create mutual understanding about the current situation, how available artefacts mediate the collaboration, and what role the visual representations play. An important characteristic of the setting is that both video- and audio conferences have been used as communication channels, which adds complexity to the meeting situation and makes our study more interesting. To investigate these issues we have looked at turn-taking both between the team members and when using the shared media space, in addition to which communication channel (i.e. video and/or audio) they use. Initiative-Response Analysis [29] helped us study the turn-taking.

1. Related Work

A shared view of the collective work is fundamental in order to be able to coordinate activities, and it is critical for the collaboration itself [10]. What Dourish and Bellotti [10] refer to as 'awareness', we here call *shared view*. They define it as an "understanding of the activities of others", which in turn provides a "context for your own activity" ([10], p. 107). An important part of all collaborative work is to maintain both a shared view and a shared understanding at least to some degree, so that the team members can perform the work and reach common goals. Collaborating teams continuously face the task of constructing a common cognitive environment; that is, team members must determine and represent relevant information that enables them to have a shared vision of the work situation [22]. In long-term collaborative activities the team members must establish and maintain a shared awareness of their actions, plans, goals and activities [34]. *Mutual knowledge* refers to knowledge that the team members both share and know that they share [22].

Demonstrating the activity to the other team members is an efficient mechanism for establishing a shared understanding within the group [13]. The visual information that is presented to the other team members "provides a situational awareness that may change both the structure (e.g. who is speaking) and the content (e.g. what is said

when) of the interaction" ([13], p. 488), and the use of visual tools may even reduce the need for some language.

The main advantage of visual information is that it allows the team members to have a shared view of the work, and this has been shown to be more important than seeing each other. Still, we do not know enough about the mechanisms and features that improve the performance in a shared visual space [24].

1.1. Grounding for Reaching Mutual Understanding

The process of accomplishing *mutual understanding* between people is called *grounding* (cf. [8]); this is an interactive process in which individuals maintain and construct a common ground. The concept has roots in linguistics and cognitive psychology, and focuses on the use of language to reach mutual understanding. The language use is described as a joint action carried out by people acting in coordination with each other and it consists of both individual and social processes [40]. However, rather than focusing solely on the language, the approach also looks at the ways in which people organise interactions in order to create mutual understanding [40]. The environment is also part of this process at it provides the team members access to the same information; it allows them to see and hear the same things [9].

Grounding is part of a "refinement process" through which the actors refine and become more and more exact in what they mean over time [4]. The common ground is augmented when new related information is added, either through the tools, the goal, the setting, or the individuals themselves [6]. Constraints and "costs" change in the collaborative situation depending on which medium is used; to different extents each medium supports *co-presence* (ability to see the same things), *co-temporality* (ability to receive messages at the same time they are sent), *simultaneity* (whether all parties can send messages at the same time or must take turns) and *sequentiality* (whether the turns can be kept in a sequence) [6]. But collaborative work is not only dependent on the available media; the composition and the dynamics of the group shape the collaborative work. People also use social representations [33] – socially and shared knowledge – to guide and orient their actions and social relationships [1].

1.2. Shared Work Environments

The work environments we are studying are characterised as supporting collaborative work, co-located as well as distributed, where there are public and private displays, and where it is possible for team members to share information in several ways. We have chosen to call these kinds of environments *interactive spaces*, to stress the possibility of conducting teamwork in a more flexible way. When designing and constructing such environments it is important to have a global vision, and part of this is that the users are not interacting with single objects but with the environment as a whole. This way of viewing technology and of interacting with resources leads to a broader way of thinking about design (cf. [30, 45]). Prototypes of environments that implement, demonstrate and exemplify those ideas can be found in [19, 25, 27, 38, 40, 42, 46].

In this paper we focus on geographically distributed meetings, which take place in workspaces characterised by large displays and tools for sharing information. During the meetings the team members are present in video and audio or in audio only. Several studies have explained the role of audio only in a distributed setting [16], the role of

video for remote collaboration [18], and how large displays supports teamwork [32]. Mantei et al. [31] have studied the use of a media space that integrates video, audio and a shared tool for collaborating at a distance. They looked at the technical obstacles, and the social and psychological impact of the technology. One of their conclusions was that they see a relationship between the size of the video image and how the other team members perceived each other. The team members who were presented with small images were less effective in the conversation. Olson et al. [35] studied teams of three people who were conducting a design task during a 90-minute period, first co-located and then remotely. To accomplish the task they used a software tool that enabled them to the share workspace, and to communicate verbally at a distance they used either video and audio, or audio only. They found that with video the quality of work was the same as in the co-located situation, but that using audio alone made the work slightly but significantly worse compared to working co-located.

2. Method

2.1. General Description of Corpus

Between April and December 2004 we followed nine meetings of an international research network that consists of ten laboratories spread out across Europe and North America, and about twenty team members are part of the network. All the laboratories have access to interactive workspaces. The teams are not working on a common project but they do exchange ideas and knowledge between the labs on a regular basis. Every month they have a geographically distributed meeting.

They use a multiplex videoconferencing system to transmit video and audio; an audio conference system is available in case the video link fails (or if someone who is away from the office wants to connect). They have also access to a shared media space and a wiki[2] website to share information; both are accessible on the Internet. They use the wiki site mainly to store internal information about the team members and the labs, along with meeting dates and agendas; this information is primarily used between the meetings. General information is available to individuals who visit the page. The media space on the other hand is used as an information resource, a place to where they can upload and download documents such as their presentations and working documents. The media space is used during the meetings and functions as a shared virtual workspace where everyone who is logged in can work simultaneously. One restriction is that only one person at a time can manipulate a document. To handle meta-communication and silent support during the meetings the team members use an instant messenger, to which they log on before the meetings begin.

Normally the laboratories use two screens to display different information: one shows the team members who are present on video and the other displays the shared media space, where usually at least one of the screens is large. Figure 1 shows the meeting situation at Laboratory of Design for Cognition (LDC); the video connections are shown on the left screen and the shared media space on the right one.

[2] Wiki is a type of server software that allows invited users to create, add and remove web page content while using any browser (http://wiki.org/wiki.cgi?WhatIsWiki)

The meetings are divided into two parts. During the first part, for which 45 minutes is reserved, all the labs are to be connecting and technical issues are discussed. The second part, which lasts about an hour, is the research seminar: network activities and research is presented and discussed.

Figure 1. Meeting situation

2.2. Data Collection

We recorded all the meetings from LDC. We used two to four fixed cameras in order to cover different angles in the meeting space: one camera for the shared media space, one for the screen that shows the videoconference picture, and finally one or two for the local space. We also used a 360° angle camera and ceiling cameras to position the local participants, and at two of the meetings one of the participants used a wearable camera ([26] describes the wearable camera)**,** but we do not include data from those cameras in this analysis. The data collection consists of about 18 hours of video recordings.

Before and after the meeting questionnaires[3] were handed out or e-mailed. The analysis reported on here draws on one of the questions, addressing the personal objectives of the team members in attending the meetings.[4]

2.3. Data Analysis

Interaction Analysis (IA) [20] has inspired our analysis, but we did not use it exclusively. IA is a useful guide for studying the interactions between humans and their resources, and it concretely describes how to approach video material. In this analysis the collaborative viewing or reviewing sessions have been somewhat limited; in IA they represent a core activity.

Our work is based on Initiative-Response Analysis [29], which discusses the dialogue or multiparty communication – a neutral term is 'communicative activity'

[3] Valery Nosulenko and Lena Samoylenko have created the questionnaires in cooperation with LDC.
[4] This was asked in the pre-meeting questionnaire.

([29], p. 7) – in terms of initiatives and responses. We have focused especially on how people make an initiative to introduce a new episode [21]. The unit of analysis is the *turn*, and it is a useful model for understanding the global aspects of communicative activities in which the turns are relatively short. The initiative is an attempt to request**,** claim or dominate and it refers forwards; the response refers backwards, and can be more or less immediate. In contrast to many other theorists, as e.g. [41], Linell and Gustavsson [29] do not talk about 'follow-up moves' or evaluation of utterances. They mean that all utterances could be defined as either an initiative or a response. A 6-level system is developed to evaluate how strong or weak the initiatives and responses are; ranging from a free and demanding initiative to an inadequate response [29]. For our purposes we have restricted the analysis to the following four levels: *strong initiative* (introducing a new topic and explicitly requesting a response), *weak initiative* (introducing new content by claming something that possibly requests a response), *extended response* (response which adds new content to the preceding turn, or implicitly asks for a response) and *minimal response* (response without any initiative).

Five of the meetings were transcribed with regularly indicated time stamps. During the transcription and analysis, we have noted the most interesting episodes. The notes covered a wide range, from what was monitored or manipulated on the displays to social interaction between the team members. Our main foci for analysis were (in line with [20]): 'Beginning and Endings', 'Turn-taking', 'Trouble and Repair', and 'The Spatial Organization of Activity'. The latter three categories are particularly useful for understanding how the workspace supports the participants.

We re-transcribed the parts we thought to be most interesting, adding detailed information, including the exact time stamps for beginnings and endings. We divided the excerpts following the work of [37], but modified the format slightly. The 'Transcript of Interaction' does not indicate the times of pauses in the talk; instead some actions have been added in brackets. The 'Characteristics of Action' clarify the action in a more abstract way where we have identified a number of categories relevant to the communication: information request, information delivery (positive/negative), confirmation/accepting, action request, accepting request, refusing request, action verbalisation, social interaction, interaction management and situation verbalisation. We also added a column for comments regarding the utterance: whether it was an initiative (I) or a response (R), and to which line (L) each turn referred. In the excerpts presented in the results all names and personal information were changed or replaced by 'x'.

3. Results and Analysis

In this section we focus on how team members create shared understanding and how the shared workspace supports their work. A short description of the work process and the activities of the team, provided in 3.1, will help to understand the results and the analysis.

3.1. Character of the Meetings and Meeting Activities

The meetings are a blend of formal and informal aspects. They are formal in the sense of having a clear meeting time, a chair, an agenda, and a procedure for getting

connected. But they are also informal: the team members – specially the lab managers – know each other very well and the meetings function as a way to keep in touch. The number of participating teams may differ from one meeting to the next, but generally 4 to 7 teams are present in at a given videoconference, and sometimes one or more teams are present in audio. Anywhere from 11 to 19 team members have participating in various meetings.

In the first meeting we studied, in April, most of the team members were present at one conference venue (i.e. outside the laboratories), and only two teams (three participants) were present on video from their labs (a third lab was connected to handle the technical support). This meeting differed from the others because it was more like a co-located meeting that uses a videoconferencing system to connect a few distant team members (including a shared media space). In the other meetings the labs were geographically distributed from each other: in these situations the difference was instead whether the teams were present on video and audio, or only on audio.

As mentioned earlier the network uses these occasions to share information and expertise, through both discussions and presentations. The items they have discussed over time include isolated items like preparations for a workshop or conference, and more long-term issues like technical solutions essential to their work and ways to improve the meeting situation. The research presentations were made either by someone within the network or by an invited researcher.

3.2. Sharing Resources and Taking Turns

The setting of the meetings includes several technical resources that make the meetings possible; the video- and audio conference systems, the shared media space, the instant messenger (IM), and the wiki site (which is mainly used between the meetings). The labs also use large screens so that all participants at a given site have the same view.

Using the media space requires a few instructions, but after that participants encounter few problems. The media space is mainly used to show presentations, and when a page is turned in a document it is turned for everyone who is logged in. During the June meeting they have decided to use an instant messenger to handle meta-communication; Section 4.4 describes how the decision was made. Excerpt 1 is an introduction to Excerpt 2, where they changed the focus from downloading the IM and creating a user account to making the usernames available to the others.

Excerpt 1. June meeting: From talking to action

Time 0:26:14	**Person, team, mode**	**Transcript of Interaction**	**Characteristics of Action**	**Comments**
1	Olivier, #1, video	"Jenny, do you have, you have your name?"	Information request	Strong I
2	Jenny, #3, video	"Almost."	Information delivery (negative) (indirect verbalisation of action)	Minimal R to L1
3	Olivier, #1, video	"Okay."	Confirmation	Minimal R to L2
4	Jenny, #3, video	"Maybe… ah okay [*typing sound*]. Okay… Okay, my screen name is jenny-s-d."	Information delivery (positive), Action verbalisation	Extended R to L1
5	Peter, #2, video	"Can you type it into the, the, into the x server, there is the document opened,	Information request + Action request (action verbalisation)	Strong I (to subtask)

		that I just opened up on the x server, where you just showed your presentation."		
6	Jenny, #3, video	"Okay."	Accepting	Minimal R to L5

End of Excerpt: 0:27:06

In Excerpt 1 Olivier took a strong initiative (line 1) by asking Jenny about her username. A few turns later Peter also took a strong initiative (line 5) to make this information visible to all team members by opening an Excel file where they could collect the usernames (since this information was of interest to everyone). In the continuation, in Excerpt 2, we see that this led to a conflict over taking turns when several team members wanted to type into the document simultaneously. The excerpt also shows how human communication can help to overcome the limitations imposed by the technology. Note that Andy is participating only on audio.

Excerpt 2. Direct continuation of Excerpt 1: Taking turns in the shared media space

Time 0:27:06	**Person, team, mode**	**Transcript of Interaction**	**Characteristics of Action**	**Comments**
7	Peter, #2, video	"Andy, can you do that too?"	Action request	2nd (strong)[5] I (to subtask)
8	Andy, #9, audio	"So, okay… [*typing sound*] [*pause*] I'm trying to type, it is not taking it." [*typing sound*]	Confirming/accepting Action verbalisation	Extended R to L7
9	Eric, #4, audio	"Maybe too many people are trying to type?"	Information delivery	Weak I (problem identification from L8)
10	Olivier, #1, video	"Here is mine, okay?"	Information delivery Action verbalisation	Extended R to Peter's I in L5 and L7
11	Andy, #9, audio	"Sorry, I just deleted it!"	Information delivery Action verbalisation	Extended R to L10
12	Olivier, #1, video	"Hey, it's okay! [*laughs*] I'll finish it and give you back the hand."	Accepting Interaction management	Expended R to L11 (organising the turns)
13	Andy, #9, audio	"Okay, thank you."	Confirmation/accepting	Minimal R to L12
14	Eric, #4, audio	"Okay, who's next?"	Accepting and interaction management	Weak I
15	Andy, #9, audio	"Okay, I'll do mine next."	Interaction management	Extended R to L14
16	Eric, #4, audio	"Okay."	Confirmation/accepting	Minimal R to L15

End of Excerpt: 0:27:48

Excerpt 2 illustrates several things. First, it shows how a conflict can arise in turn-taking in the shared media space if more than one person tries to type simultaneously (Olivier and Andy, in lines 8 and 10). Eric recognised this problem and informed the others (line 9), but no one was paying any (explicit) attention to this. When only one person can be active at a time, the turns have to be organised so members can complete their tasks (lines 14-16). The way the team solved the conflict was by letting everyone

[5] Since this is a repeated request it is less strong, but on the other hand it is directed to another person.

provide his or her usernames to Jenny, who typed them into the document. But as we will see later on in the meeting (see Excerpt 6 in Section 3.4), they did not complete the task of collecting usernames.

The turn-taking conflict is probably related to the fact that the participants do not share the same physical space. In the two excerpts we see that the participants were verbalising their actions (indirectly as in lines 2 and 5 and directly as in lines 4 and 10-12); in this way they overcame the difficulties of not being able to see what was happening in the media space. This illustrates the need to support the action in a shared, but geographically distributed, space. In the following section we will see other effects of not sharing the same physical space.

3.3. Sharing the View – Understanding the Situation as a Whole

Each team member can only completely view his or her own local situation; that is, they can tell who is attending locally, what they have access to (media space, IM) and the quality of sound and picture. The lab that is organising the meetings as well as connecting the other labs using video and/or audio is the one that can best understand the whole situation. Normally the chair explicitly shares his knowledge about the presence of the participants with the other team members (compare this to Excerpt 5, lines 1-3, in Section 3.4). They also use the IM to share the fact of their presence and other relevant information (e.g. connection problems). To be recognised as present is especially important to the participants in an audio conference, but those in the videoconference also need to know who is present only on audio. In Excerpt 3 we will see a somewhat different situation as one team member, Wolfgang, explicitly asked for confirmation of a particular person's presence in one of the other labs.

Excerpt 3. November meeting: Checking presence

Time: 0:04:12	**Person, team, mode**	**Transcript of Interaction**	**Characteristic of action**	**Comments**
1	Wolfgang, #4, video	"In the middle of the table [*directed to team 1*] do I see John?"	Information request	Strong I (clarifying vision)
2	John, #1, video	"Yes, you do!"	Confirmation	Minimal R to L1
3	Wolfgang, #4, video	"Oh, hello! How are you?"	Social interaction	Minimal R to L2 + weak I
4	John, #1, video	"I'm fine. How are you?"	Social interaction	Extended R to L2 + weak I
5	Wolfgang, #4, video	"I'm well. I can't complain. I have also been to Paris recently."	Social interaction	Minimal R to L4 + weak I
6	John, #1, video	"Oh, good."	Social interaction	Minimal R to L5

End of Excerpt: 0:04:26

Wolfgang asked that question not only to get a clarification because the picture might be fuzzy, but also because he had not expected to see John on Team #1: John is part of Team #3. Such clarifications are not rare; at most meetings people want to clarify how is present. But it is not only a question of who is there and who is not; people also need to understand who has access to the shared media space and be sure that everyone can see and hear well. Some amount of time in each meeting time must

be devoted to handling such issues, although the amount has decreased with experience. Excerpt 4 illustrates how the chair, Olivier, ensured that the other team members could see and hear before he started his presentation.

Excerpt 4. November meeting: Seeing and hearing well

Time: 0:10:42	**Person, team, mode**	**Transcript of Interaction**	**Characteristic of action**	**Comments**
1	Olivier, #1, video	"I will start today's presentation. And it's, it's about eh… [*opens the presentation in the media space*] All right. Can everybody clearly see what I am presenting?"	Interaction management Information request	Weak I Strong I
2	Wolfgang, #4, video	"Yes, could you…?"	Information delivery (positive), and information request	Minimal R to 2nd part of L1, tries to make an strong I
3	Olivier, #1, video	Does everybody hear me correctly?"	Information request	Strong I
4	Nils, #7, audio	"Yes."	Information delivery (positive)	Minimal R to L3
5	Jenny, #3, video	"Yes."	Information delivery (positive)	Minimal R to L3
6	Wolfgang, #4, video	"Yes, could you speak slowly?"	Information delivery (positive) and information request	Minimal R to L3, and 2nd trial to make a strong I (1st try in L2)
7	Olivier, #1, video	"I will speak slowly.	Information delivery (positive)	Minimal R to L6

End of Excerpt: 0:11:15

Once Olivier had gotten the confirmations from each team member about the acoustic and visual conditions he started his presentation.

3.4. Physical Space Matters – What does it Mean to Participate in Audio?

The following two excerpts are taken from the same meeting: the team members discussed how to handle the communication between the labs when both the video and audio channels fail. A solution has been raised at an earlier meeting: use an instant messenger. Peter, who was present on video, was proposing different possibilities – including using AOL [2] – but he had not received any clear response. Excerpt 5 illustrates that when a team member is present only on audio he can shift quickly, not only from unknown to known, but also from unknown to leader of the discussion.

Excerpt 5. June meeting: Going from periphery to main actor

Time 0:19:45	**Person, team, mode**	**Transcript of Interaction**	**Characteristic of action**	**Comments**
1	Olivier, #1, video	"I, I think hmm… Andy? Did you join us, Andy?"	Information request	Strong I
2	Andy, #9, audio	"Yes, yes I am here."	Information delivery (positive)/confirmation	Minimal R to L1
3	Olivier,#1,	"Yes, you are here, okay…	Situation verbalisation	Extended R

	video	because the others were not aware that, that you had come in, so… I was the only one to know so I share the news."		to L2
4	Andy, #9, audio	"Well, thank you. Although I sent, sent both you and Peter my AOL screen name. So since AOL is free and accessible I would recommend that a simple e-mail message with everybody's AOL screen name on would be really handy."	Social interaction Information delivery	Strong I
5	Olivier, #1, video	"Okay."	Accepting request	Minimal R to L4
6	Peter, #2, video	"Yeah."	Confirmation	Minimal R to line 4
7	Olivier, #1, video	"That's, well that, that would be the same thing as Peter's suggestion, right?"	Information request	Weak I (clarifies the statement of Andy, L4)
8	Andy, #9, audio	"Yes, that's basically the same."	Information delivery (positive)	Minimal R to L7
9	Olivier, #1, video	"Correct."	Confirmation	Minimal R to L8
10	Andy, #9, audio	"Although we could, we could do it in five minutes."	Interaction management and Action request	Strong I

End of Excerpt: 0:20:26

The above example shows how Andy very effectively used the door that Olivier opened to him (lines 1 and 3). As we see, being "invisible" does not automatically mean that it is more difficult to influence the group; perhaps it is a question of how things are said and who is saying them. In this case Olivier made a strong initiative to introduce Andy, who immediately continued on the same topic as Peter, who had been arguing unsuccessfully to choose AOL, just before Andy was introduced. But once Andy entered the stage, he started (line 4) by stressing that he had already taken an action (sending out his AOL user name to the others). Andy was recommending this action without arguing for it (lines 4 and 10), and Peter supported him (line 6). In line 7, Olivier took a step back to compare Andy's statement to what Peter had said earlier. In this way Andy actually led the group to choose AOL, although they did not make a formal decision, in the sense of all team members agreeing upon this particular service. In fact, after this episode the team members who did not have an AOL user account got one and then they collected the usernames in a document (illustrated in Excerpts 1 and 2, Section 3.2). This activity however, did not take the "five minutes" that Andy estimated (line 10), but rather about 25 minutes of meeting time.

In Excerpt 6 we illustrate how a team member, who is participating only on audio and who has "been forgotten", has invisibly contributed to the overall goal of the team (to collect the usernames).

Excerpt 6. June meeting: Forgotten in the audio

Time 0:46:42	**Person, team, mode**	**Transcript of Interaction**	**Characteristics of Action**	**Comments**
1	Olivier, #1, video	"By the way, Thomas, are you still there?"	Information request	Strong I

2	Thomas, #5, audio	"I am still here, yeah."	Confirmation	Minimal R to L2
3	Olivier, #1, video	"Okay, because I realized we have forgotten you for a while, nobody has asked you for your, you know, AOL name."	Interaction management	Weak I
4	Thomas, #5, audio	"Well, I've put it in the list."	Information delivery	Extended R to L3
5	Olivier, #1, video	"Oh!"	Accepting	Minimal R to L4

End of Excerpt: 0:46:56

Olivier, the chair of the meeting, realised that Thomas had been forgotten (line 1), and specifically asked for his username, but Thomas had already typed it into the shared document, just after the others had finished doing so. This initiative was "invisible" in two ways. Thomas was literally not visible to the others because he was present only on audio, and the shared media space did not indicate that someone was using it.

4. Discussion

In this paper we have focused on the role of visual representations during geographically distributed meetings in shared interactive spaces, and on the ways that team members create mutual understanding about the situation. Our approach has been to analyse the initiatives and responses made by the team members.

In the first two excerpts we saw how the team used the media space to share information easily with the other team members. Hindering the process is in fact that only one person can work actively at a time. That fact led them to organise the turns, which both interrupted the meeting and inhibited the sharing of information. This conflict revealed a gap between the individual and the system (the lack of any indication that someone else is using it at any given moment) and therefore also between the team members (see Excerpt 2, lines 8-11). This illustrates that the system does not give the users enough feedback for them to understand the activities of the others [10], or a shared view of what is happening in the system. The workspace should "communicate who is working in the space and what they are doing" ([36], p. 70), which clearly did not happen here. This finding might help explain why Thomas, Excerpt 6, contributed after the others; it would have taken too much effort to intervene whilst the others collected their user names. If this is the case it confirms that what the medium allows us to see and do affects how we communicate and interact [12].

We also noted in the first two excerpts that the participants complemented their actions by articulating what they were doing (indirectly in lines 2 and 5, and directly in lines 4 and 10-12).[6] In this way they helped the other team members to remain aware of the ongoing action [34]. This would probably also happen to some extent in a co-located setting, but we think this is an effect of not having a sufficient overview of what is taking place in the shared and geographically distributed workspace. This same problem of not sharing the physical space underlies the repeated questions about who is

[6] [15] also has identified that participants compensates for the shortcomings of the system by spoken account.

present and who can hear and see well (as illustrated in Section 3.3), which is a basic requirement for creating a common ground between collaborating people. We think this problem is exacerbated by the fact that they are not all co-present [6]; some participants are connected via audio and video and some via audio only. This *blended* quality makes the meeting situation more complex and cognitively more demanding for both the chair and the other participants.

We also see a limitation on how many people can be active in the communication space at the same time in this distributed setting. In Excerpts 2 and 4 we saw team members have trouble making their voices heard when too many were trying to make contributions simultaneously. In Excerpt 2, line 9, Eric was making a weak initiative without getting his voice heard; his polite request in line 14 can be interpreted the same way. We can see this request as the result of his participation in turn-taking, but he does want to share his usernames with the others. We interpret his request in this way because later on, 10 and 11 turns after the end of the excerpt, he tried again, asking "Okay, is it my turn, Olivier?" and "Is it my turn now?" In Excerpt 4 we see how Wolfgang tried to make a weak initiative and succeeded after his second attempt (lines 2 and 6). As long as only two or three people are interacting there is no problem (as in Excerpts 1, 3, 5 and 6), but when more than three try at once, it is apparently more difficult. Obviously it is also easier to enter the communicative space when someone is making a direct request (strong initiative), as we see in Excerpt 2, lines 7-8, and in Excerpts 3 and 6.

In our earlier study in a co-located setting we saw how team members used different interactive resources to contribute to the common work [43]. In addition we noticed that the team members preferred different ways of expressing ideas and contributing to the work. This in turn indicated that this kind of environment even might lead to equalising the roles of the team members. The teams also had many ad hoc discussions, and in several situations non-linear relationships developed between initiatives and responses. This was illustrated by the fact that even peripheral team members could make major contributions to the overall work although they had initially been given no attention. We have not, yet, been able to see these phenomena in this corpus. These phenomena might not have occurred because the meetings had agendas and were more structured; however we also think this is an effect of the distributed setting. Instead of the roles each team member becoming more equalised, they become accentuated in the distributed setting, as each initiative and response is received either more weakly or more strongly than it would be in a face-to-face situation. This is probably also related to the status or the role of the team member in the group.[7] If this is so, it supports [5] in that material resources are part of the determination and distribution of roles between the participants. It would also support the work of [14], who suggest that team members can communicate and exchange information more effectively if community systems were to support role-mechanisms (e.g. role-assignment, role-taking and role-making).

As these examples show, two key elements of grounding [6] – the lack of feedback on the others' situation, and the inability to monitor the state of one's own team members – create problems in developing mutual understanding. Thus, it is not enough to allow participants to see the actions of the others; they also need too know what

[7] Other relevant aspects include intonation and the way something is said, but those are not our focus in this work.

remote participants can see in the shared workspace [13]. Excerpt 6 illustrated one consequence of this when a team member was forgotten, probably because he was present only on audio and not in the videoconference. Not only is this important for creating a mutual understanding between the team members; we also see another, more pragmatic, issue. The repeated questions about who is present and who sees what take energy, focus, and time from the main objective of the meetings. Kraut et al. [23] reported that it is more important to share the view of common objects than to see each other, but we would modify this: depending on the setting it is also essential to also a view of all the participants and not only of the shared objects. In our specific case this might be related to the number of participants, or number of teams, or the fact that using audio conferencing as a backup confuses the situation. On the other hand we also saw in Excerpt 5 that this does not by default make major contributions more difficult, though we point out the great value of ensuring that an audio participant is introduced to the others at the beginning.

We will continue to study turn-taking and making initiatives in relation to the mode of presence (through video and audio, or audio only). In particular we will look at a situation when a large part of the group is located in the same place. We will also look more deeply into how the team members develop the social conventions they need to work in a shared but distant interactive workspace.

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