Seeing eye to eye: an account of grounding and understanding in work groups

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Abstract

This paper reviews seven years of work on small group discussion at the Human Communication Research Centre, Universities of Edinburgh and Glasgow, UK. Our thesis is that difficulties for decision-making in work groups can be characterized in terms of properties that disrupt the dialogue processes by which people establish common ground. Using an inter-disciplinary research cycle consisting of field observation, the collection of corpora of small group discussions from workplace settings, questionnaires about communication practices, and laboratory simulations, we explore this thesis for three factors we have observed to affect group communication — group size, status differences, and organizational structures which cut across the group membership — and describe what we think should be research priorities for the coming years.

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1. Introduction

How people establish common ground has primarily been studied in the laboratory, concentrating on face-to-face, two-person dialogues. Despite this laboratory focus, the grounding process has important ramifications for many kinds of real-world communication, including telephone conversations (Clark & French, 1981), videoconferencing (Daly-Jones, Monk, & Watts, 1998; Doherty-Sneddon et al., 1997), text-based computer-mediated communication (Hancock & Dunham, 2001), spoken dialogue systems (Brennan & Hulteen, 1995), and surveying (Schober & Conrad, 1997). In this paper we apply what is known about the grounding process to groups operating in the workplace.

Guzzo and Dickson, in their excellent review, define a "work group" as "made up of individuals who see themselves and who are seen by others as a social entity, who are interdependent because of the tasks they perform as members of a group, who are embedded in one or more larger social systems (e.g. community, organization), and who perform tasks that affect others (such as customers or coworkers) (Guzzo & Dickson, 1996 pp. 308-9)." Work groups are an important area of study simply because they are the mainstay of decision-making in organizations ranging from corporations to government and beyond. Anything that affects their performance or the decisions they make can have an impact on the well-being of many more people than just the group members.

In a static environment, organizations can survive merely by continuing to behave in ways that they have previously found successful. However, the modern world is not static; it changes quickly and unpredictably. Successful organizations bring together groups of people who jointly have all the skills and knowledge to design and implement strategies for adapting in the light of environmental change (Katzenbach & Smith, 1993). These groups cannot operate without good communication, since otherwise the members are unable to behave in a concerted manner. However, what is required is not just an amount of communication, but a particular form. In these groups, decisions must be taken by the entire group and not by a group leader in consultation with the other members (Vroom & Jago, 1988). True group decisionmaking ensures that every group member understands the multiple facets of a problem and freely expresses their insights towards a solution, as well as increasing the group members' commitment to the solution chosen by the group. But group decisionmaking and consultative decision-making require very different kinds of group communication. Group decision-making requires all of the group members to communicate with each other, but consultative decision-making only requires links between each member and the group leader.

In this paper, we take three common properties of work groups — large size, the existence of relative status differences among group members, and divisions within the organizational structure in which the group is embedded — and explain why they make group decision-making difficult. Our thesis is that these properties operate by disrupting the grounding process by which group members come to understand each other. We first explain what grounding means for groups by extrapolating from the model for dialogue, and then describe how this disruption occurs.

2. Grounding in dialogue and group discussion

When two people converse, they cannot possibly exchange all of the information necessary to ensure that their utterances are understood as intended. Instead, speakers assume that they share some "common ground" with their hearers. Clark and Schaefer (1989), quoting from Stalnaker (1978), define common ground as consisting "the propositions whose truth he [the speaker] takes for granted as part of the background of the conversation (p. 260)." As a conversation progresses, speakers presuppose the propositions which were conveyed in previous utterances, adding to the common ground. Thus the net effect of a conversation is to increase the amount of information that the conversants share.

Of course, it is possible for the presupposition that a proposition is in the common ground to be incorrect. The conversational strategy of assuming common ground only works because conversation is highly interactive, with participants able to alter the course of the conversation almost immediately when they notice a problem. Clark and Schaefer argue that both speakers and hearers must act to ground a contribution. Even when understand a contribution, they explicitly signal acceptance by, for instance, continuing to pay attention, initiating a next, relevant contribution, or acknowledging the utterance. As a result, even people who fully overhear a conversation do not understand what was said as well as the people who actually took part in it (Schober & Clark, 1989). This is because overhearers are unable to affect the course of the conversation, and most crucially, to indicate when they do not understand. That is, monitoring and being monitored by the speaker so that one is able to intervene by making a dialogue turn when communication goes wrong is essential to ensuring that understanding takes place.

Grounding in dialogue requires close mutual monitoring between the conversational participants. In face-to-face English conversation, the speaker tends to look away from the hearer whilst planning an utterance, gazing at the hearer in order to monitor uptake once the initial planning is over and the words are being formulated and synthesized (Kendon, 1967). Meanwhile, many speaker behaviours (e.g., the completion of syntactic constituents and of gestures) predict when the speaker is coming to the end of an utterance (Duncan, 1972), allowing the hearer to signal acceptance or to intervene in a timely fashion. Although communication is possible without visual monitoring, it is more difficult; turn-taking is still relatively close in audio-only dialogues, but participants rely on more explicit grounding techniques such as eliciting verbal feedback (Doherty-Sneddon et al., 1997) and some disruption, such as a change in the rate of interruption, is discernible (Boyle, Anderson, & Newlands, 1994). In different languages and cultures, the details of the turn-taking process and the speed of turn exchange differ (for instance, see Tanaka, 1999 for a description of turn-taking in Japanese), but relatively close interaction is the norm.

Theories of group discussion treat it as an extension of dialogue. One prominent model of turn-taking in groups (Sacks, Schegloff, & Jefferson, 1974) privileges dialogic communication by suggesting that the current speaker can nominate the next one, and only if this nomination does not occur will there be a free competition for the floor. Another prominent model (Stasser & Taylor, 1991) assumes that the likelihood of someone speaking decays with the number of turns in the discussion since he last spoke. The purpose of this assumption is to match observations of speaker sequencing in four-person group discussions which suggest that they can best be

characterized as a series of pairwise conversations that are interrupted by the remaining participants in attempts to establish new pairings (Parker, 1988). Like dialogue, discussion uses visual monitoring to govern turn-taking, providing some evidence that dialogue and discussion operate in similar manners. In a three-person discussion, speakers make a prolonged gaze at someone else when they are coming to the ends of their turns, and the participants at whom they gaze are more likely to speak next (Kalma, 1992). The behaviours group members employ when they wish to take a turn in a discussion — backchannel utterances, hand gestures, and postural shifts (Beattie, 1985) — might all serve to draw the speaker's eye. Group communication technologies which disrupt eye contact also tend to disrupt turn-taking (O'Conaill, Whittaker, & Wilbur, 1993).

One argument mitigates against discussion using the same mechanisms as dialogue it is not clear how these mechanisms would scale up as group size increases. In large groups, it is difficult to monitor individuals or notice attempts to take a turn. This in turn is likely to affect participant behaviour. Boden (1994), for instance, notes that participants in larger groups produce fewer backchannel utterances than those in smaller ones. Large groups are dispreferred for free discussion; much management training emphasizes the need to keep discussive meetings small and focussed (Chang & Kehoe, 1995; Doyle & Straus, 1976). Homans (1951) suggests that in settings such as cocktail parties (or, in his case, gang members congregating on street corners) where small groups can form and rearrange freely, drawing from a pool of participants, they naturally split when the groups reaches roughly five people. (Dunbar, Duncan, & Nettle, 1995) notes the same rough split when observing student behaviour in a cafeteria, although they explain it in terms of the number of simultaneous voices one can monitor. (Hare, 1952) observes that groups of twelve break into cliques more often than groups of five. If small groups do follow dialogue in requiring close monitoring for their turn-taking and grounding, then discussions in large groups may be quite different.

3. Ramifications for work groups

If discussion is an extension of dialogue, with the same reliance on close monitoring for understanding, this has important ramifications for work groups. For group decision-making, all group members must understand each other's contributions. Ideally, all communication would occur with all group members present, and after each contribution, every hearer would have the opportunity to explore aspects of the contribution that he did not understand. However, group communication simply is not like this.

3.1. Distortion of grounding

First, group discussions do not fully explore every contribution before moving on to the next one; one person is either nominated by the current speaker or wins the competition for the floor at any one point (Sacks et al., 1974), and whatever is said moves the discussion on. Since it is difficult to return to a previous conversational thread, this automatically places everyone who did not get the floor at a disadvantage for understanding the previous contribution.

As we have noted, Parker (1988) observed that pairwise patterns tend to occur in the speaker sequences of group discussions. If there are any properties of work groups that make certain individuals or pairs more likely to appear in this patterning, then this would tend to distort the group grounding process, privileging those individuals in understanding the group's business, or creating greater understanding among those pairs. The presence of relative status differences among group members is one candidate for creating this distortion. Individuals in work groups have a relative status which is derived both from relatively static factors such as their position in the organizational hierarchy and their social status and from the expertise and skills that they bring to the task at hand. Status characteristics theory (Berger, Fisek, Norman, & Zelditch Jr, 1977; Berger, Rosenholtz, & Zelditch Jr., 1980) describes the effect of relative status differences on both dialogue and group discussion. At least in Western observations, in both dialogue and group discussion high status people speak the most and produce most of the utterances that determine the course of the discussion by initiating topics and discourse goals. This means that high status individuals are more likely to understand and be understood than other group members.

3.2. Reduction and distortion of grounding opportunities

Second, not all communication involves the entire group in face-to-face discussion. Groups find it difficult to meet as a whole. This is especially true if they are large, but it also applies when groups draw members from different places. The modern organization is rarely a monolithic set of individuals. Universities are structured by academic discipline, companies by function (sales, personnel, production, and so on), hospitals by medical specialty. Organizational hierarchies are drawn within these lines, and offices are usually assigned so that employees from the same part of the organization sit together. Even if different functions share the same physical site, quite short distances and small physical barriers greatly reduce the amount of communication that goes on (Allen, 1977; Kraut, Egido, & Galegher, 1990). In addition, globalization has increased the number of industrial organizations that contain employees who are not col-located, and the number of co-operative ventures that draw group members from what are essentially different organizations. Groups remedy this difficulty in two ways.

Sometimes groups that cannot meet all together choose to meet with people missing. In this case they often also rely heavily on informal communication among their members (Whittaker, Frohlich, & Daly Jones, 1994). Then group members do not get to hear all contributions to the group's communication, much less ground them. This point is not, strictly speaking, about grounding; any theory about how people communicate would predict that where people do not communicate, they will not understand each other. However, it does affect the basic opportunities for grounding, and it biases the group process in favour of understanding among people from the same parts of the organization, creating cliques. It also biases the group process in favour of the higher status group members, since meetings are more likely to be cancelled when they cannot attend.

Sometimes groups that cannot meet all together still communicate as a whole, but use mechanisms that are not as good for free discussion as face-to-face meetings. Media such as memoranda and mass e-mailings give little opportunity for monitoring, feedback and clarification (Daft & Lengel, 1986). Electronic bulletin boards allow for

some discussion but even relatively rich technologies such as videoconferencing make discussion more difficult than with face-to-face interaction. Whatever media groups choose, if they cannot meet all together this reduces the opportunities for grounding and favours those connections where face-to-face communication is possible.

4. The Studies

So far, we have presented an argument, based on a view of discussion as an extension of dialogue, which suggests that some common properties of work groups will make true group decision-making more difficult. Our research questions are as follows. Does understanding really arise in a group discussion out of the same grounding process that operates in dialogue? How does this process scale up to large groups? Do relative status differences and organizational barriers disrupt group decision-making, as the theory would predict? We now present a series of empirical studies that we have conducted which bear on these questions.

Our questions carry with them methodological difficulties. One of the major difficulties in group research is ensuring that work is controlled enough to interpret, whilst still shedding light on real groups occurring in natural settings. Collecting data in naturalist settings is difficult and expensive. Because no two groups have the same circumstances and history, the resulting data set will not just be small, but also poorly controlled. This makes data interpretation fraught with difficulties. Despite this, there is no proper substitute for real data. Laboratory simulations are relatively easy to set up and interpret, but many researchers and group practitioners question their results because there are so many variables that can have major effects that these studies simply ignore. One of the most important of these is the participants' commitment to the task. In real world groups, group members have much more reason for participating in the activities of the groups than laboratory subjects in any kind of study. This may greatly affect the resulting behaviour.

In order to address these difficulties we have developed a cyclical research strategy in which we use a range of methods, relying on the interplay among them to reach our goal. Descriptive analysis of data collected in the field give us our basic intuitions about the properties of small groups. Simple observation is irreplaceable as a first step to approaching new research questions. When we have sufficient field data and an argument we wish to make from it, we rely on a sociological methodology that uses several different methods of analysis, including some quantitative measures of communication which will at least be recognizable to psychologists, to "triangulate" upon our results (Silverman, 1993). Although most of our fieldwork builds upon direct observation of groups, on occasion we also employ less onerous survey and questionnaire methods that allow us to gather less detailed information from a wider range of respondents.

When a clear hypothesis emerges from the field data that is so important that its truth and generality must be tested, then we employ controlled laboratory experiments. These can either be designed to be as close as we can get to some real setting, in which case they might be seen as a means of approximating real data in a way which makes the collection easier and disentangles some of the variables, or can generalize over many settings, giving clear theoretical results of widespread application. Meanwhile, as we establish more facts about group communication, this suggests priorities for other workplace conditions that would be fruitful topics for field studies.

Although this research strategy is perhaps unusual in the number of different disciplines upon which it draws, its strength lies in ensuring both the generality and the importance of our results.

4.1. Exploratory study: face-to-face manufacturing teams

Our first foray into work with groups was a study of teams from UK "small-tomedium sized enterprises" (SMEs) in the manufacturing sector (Carletta, Garrod, & Fraser-Krauss, 1998). Although now the word "team" is ubiquitous in Western industry, when it was first introduced, it was intended to signify exactly the sort of work group that engages in group decision-making (Guzzo & Dickson, 1996). True teams tend to be cross-functional, drawing members from across the organizational hierarchy in order to assemble all of the skills and knowledge needed for the problem at hand. Thus, for instance, as was the case for one team we studied, a team with a remit to speed up the processing of new orders might involve representatives from the parts of the company dealing with marketing, sales, logistics, technical drawing, and production. The team members might never even see each other, under the usual strictly functional organizational structure. Once the problem that draws them together has been resolved, they return fully to their usual work. Within their remit, the team members share authority jointly rather than having one "manager" who takes decisions after receiving advice. This tends to equalize the status of team members within the group.

In this study, we observed, recorded and transcribed 21 meetings of 6 different groups in 4 companies. Four of the groups were teams in the specialist sense defined; the remaining two called themselves teams, but were really traditional groups. That is, one person in them had overall authority (in both cases, the company's chief executive officer) and the rest of the group was directly beneath that person in the organizational hierarchy. This gave us the opportunity to compare the two types of work group discussion. The meetings all had between four and ten participants.

Because this work was exploratory, we set out to characterize the structure of the discussions. Figure 1 gives a pictorial representation of the two different discussion structures that we found, in terms of the number of adjacent turns made by the different pairs of meeting participants. Our analysis suggested that traditional groups behaved in the same way whatever size they were. A traditional group meeting can be characterized as a series of conversations between the group manager and various other individuals in the group, with the rest of the group members present, but silent. The conversations were usually initiated by the group manager, and little "crosstalk" between other group members occurred. On the other hand, the communication in a true team meeting depends on its size. In small team meetings, the members participate relatively equally, judging from the number of words they say and contributions they make. A small team meeting still looks like a series of two-way conversations, but every member initiates conversations, and conversations occur between all the different pairs of members. That is, no one member dominates the proceedings. Larger team meetings, by which we mean those with more than around eight participants, have patterns that are indistinguishable from traditional group meetings. They may not have an official group manager, but one person still mediates the rest of the group's communication.



Figure 1: Discussion structures in work group meetings.*

*Lines connecting participants show primary channels of communication.

Our results are merely suggestive, since the data set was small and since the larger meetings were mostly from traditional groups rather than teams. (This is a structural problem rather than an accident, since teams tend to reduce the number of meeting attendees by considering explicitly who should be present.) However, our results concerning group size accord with some very old observations of Bales et al. (1951) that the larger the group, the more one person will come to dominate the discussion. As a result of our observations, we conjecture that highly interactive discussion is less possible in meetings that are either large or differentiate members by status. If this is true, it has important implications for teamworking. The discussion structures that we observed in traditional, status-differentiated groups and large teams are conducive to consultative decision-making, but support true group decision-making less well. This is because they privilege understanding of the "leader's" utterances at the expense of other contributions.

4.2. Large versus small face-to-face groups

As a direct result of developing this conjecture, we ran a controlled laboratory simulation eliciting discussion in equal-status five and ten person groups (Fay, 2000; Fay, Garrod, & Carletta, 2000). If these two group sizes showed different discussion structures matching those for our small and large team meetings, then this would provide clear evidence that the differences suggested by the workplace study are real apply more generally. As well as collecting the discussions themselves, the study involved a method for determining how well pairs of individuals agreed on the discussion's outcome. This allowed us to test for how mutual understanding arises out of the discussion.

The participants in this study, who were undergraduates, were assigned randomly to one of ten five-person groups or one of ten ten-person groups. The participants first read a one-page fictional description of a case of student plagiarism. They then ranked a set of 13 pre-determined issues in terms of how important they were in deciding how to handle the case. For instance, one issue was whether or not in making a decision about how to handle the case, the university should take into account the fact that the student had previously always received very good marks. They next were asked to imagine that as a group they had to make general recommendations to the university about how to deal with this and other cases of plagiarism. Once the participants had completed a discussion of the case, which the experimenter suggested should take around twenty minutes, the participants were again separated and asked to rank the 13 issues, this time in terms of how important the group agreed they were to the case.

Given this data, we can measure both how well any pair of participants agrees about the issues ranking before the discussion and how well that pair agrees after the discussion about what the outcome was. If we factor out the former, the latter gives a gross measure of the degree of understanding established between the pair. Using this technique, we considered whether or not the amount of direct interaction between a pair of participants affects their agreement about the group outcome, and therefore the degree to which they establish common ground.

The results, although compatible with our field study, were perhaps surprising. In five-person groups, after factoring out the level of pre-discussion agreement on the issue rankings, participants agreed most about the group's outcome with the people they conversed with the most. This result is compatible with the theory that how common ground is established during group discussion is an extension of the mechanism for dialogue. Here, the participants understood the points of view of those with whom they interacted better than those for whose speech they were primarily overhearers¹, causing their post-discussion rankings to agree more. However, in tenperson groups, again after factoring out the level of pre-discussion agreement, participants agreed most with whoever spoke the most. Participants were not influenced more by the people who took turns adjacent to theirs. This suggests that ten-person groups do not operate as dialogues with overhearers, but that all participants have equal chances of understanding and accepting what the speaker says.

There are two possible explanations of this result for five-person groups. It could be that participants only pay attention when they are actively involved in the conversation, or it could be that something about what the speakers choose to say affects the uptake of active interactants and overhearers differently. Of course, it is the latter explanation that accords with our model of common ground; active interactants share more common ground after the conversation because they are able

¹ It is moot what to call participants who are involved in the meeting but not in the current conversation. Meeting participants who are not speakers or addressees can be considered to be "side participants" (Clark, 1996) as long as they are "ratified" (Goffman, 1976), or recognized by the speaker and addressee as full members of the conversation. However, in meetings, at any one time some participants are less involved, and less recognized to be involved, than others. Thus at any one time, a meeting participant might be a speaker, addressee, side participant, or overhearing bystander. To stress the fact that simply participating in a meeting does not necessarily afford the full interactional rights due to side participants for the duration of the meeting, we call participants "overhearers" when they are neither speaking nor being addressed.

to influence each other's utterances to be sure they understand what is said. We tested this by using the recordings of the discussions we gathered in a further study. In this study, instead of taking part in discussions, participants listened to recordings of them. Each participant performed the initial issue rankings, listened to a tape recording of a size five or size ten group, ranked the issues according to their importance for that group, and then repeated the listening and ranking for the other size group. Participants were assigned discussions that matched in length as closely as possible, with order of presentation counterbalanced across the participants. Using this design, the overhearers of five-person groups agreed with each other's assessment of the group outcome less than overhearers of ten-person groups. That is, the increased agreement for active interactants in five-person groups arises because speakers are doing something differently in these groups — that is, adjusting their contributions to their interactants — and not just because the listeners are behaving differently.

As well as differing in how influence is spread, size five and size ten groups differ in their conversational structure. Ten-person groups show fewer and shorter two-way conversations, and therefore fit Parker's (1988) characterization of discussion as a series of dialogues with overhearers less well than the five-person groups. In tenperson groups, utterances are longer, and there is less overlap in which two or more people are speaking at the same time. Preliminary analysis suggests that eye contact affordances may play an important role in causing these differences; in five-person groups, people facing the current speaker are disproportionately likely to speak next, but this is not the case for ten-person groups. These results provide more evidence that grounding is at work in five-person groups but not ten-person ones.

One obvious question is whether as group size grows, there is a gradual or sudden shift between these two kinds of group behaviour. The current leading model of speaker sequencing in group discussions (Stasser & Taylor, 1991) assumes progressive change, but is primarily based upon observations of relatively small groups. In a preliminary follow-up, we recorded three groups each of sizes six, seven, and eight and looked just at their turn lengths. Rather than showing a gradual shift from the short turns of size five groups to the longer ones of size ten, the data showed a clear split between size seven and size eight. The turn length distribution for size seven groups is indistinguishable from that for size five, as is that for size eight from that for size ten. This sudden split suggests that it would be incorrect to see the differences between small and large groups simply in terms of process losses due to grounding difficulties. Small and large groups appear to operate according to radically different processes.

4.3. Do small groups try to establish mutual understanding?

Our study of manufacturing teams, like Parker's (1988) data, showed speaker patterns which suggest that small, equal-status group discussions consist of two-person dialogues with overhearers. If this is the case, then participants should be at a disadvantage for understanding and accepting the information that was presented in the dialogues that they overheard. The laboratory experiment confirmed that for five-person groups, common ground is established better between pairs who interacted highly with each other than between those who did not. That is, when information is expressed in a group, not all group members are equally able to assimilate the information, hindering full mutual understanding. The next obvious question is

whether or not this matters to the group — do members of small groups try (but fail) to make everyone understand everything?

Obviously the setting and task for a group can have an overriding effect on the answer to this question. For instance, in the cross-functional teams from our original study, the team cannot work effectively unless team members come to joint understanding. However, to answer this question under circumstances where the need for common ground is less clear, we devised a task in which not all of the information exchanged in the group needed to be understood by all group members. If groups still try to establish common ground among all members under these circumstances, this suggests that establishing common ground in small groups really is the norm rather than some setting-imposed exception.

The study (Anderson, Mullin, Katsavaras, Brundell et al., 1999; Anderson, Mullin, Katsavaras, McEwan et al., 1999; Anderson et al., submitted) used the original, twoperson HCRC Map Task (Anderson et al., 1991) plus a variant of it adapted for three people. In the Map Task, participants each have a copy of a schematic map, either drawn on paper or presented on a computer screen. All maps show a start point and a number of landmarks. Some landmarks are common to all of the maps but others appear only selectively. The subjects are told that their maps have been drawn by different explorers. That is, all maps can be expected to be correct, but they might feature different landmarks or use different, semantically compatible names for the same landmarks. In the original, two-person Map Task, one of the maps, for the "instruction giver", also has a route drawn on it. This three-person adaptation uses two "instruction giver" maps with identical routes. The goal of the task is then for the instruction follower to reproduce the route accurately. The participants can converse but they cannot look at each others' maps. Communicative behaviour for the twoperson, face-to-face Map Task has been widely studied, including dialogue length and performance (Boyle et al., 1994). This study compared the three-person, face-to-face Map Task to additional conditions in the participants used high quality videoconference links to complete two and three-person Map Tasks.

The study found that while use of a video-conferencing link has little effect on the discussion, the introduction of a third person does. In all of the conditions the groups were able to complete the task equally well, but when three people were involved, the group had to talk more. In order to discover why, we coded each speaking turn according to whether the turn's content was entirely social; task-oriented, in that it contributed directly to completing the route; or made some sort of meta-level comment about how to complete the task, including (in the video-mediated condition) comments about the technology. Three-party video-mediated groups made more meta-level comments about the technology than groups in the other conditions, but, since these comments are fairly rare, making up 1% of the total turns, only around 10% of the extra talk in three-person video-mediated groups can be accounted for in this way. Of course, extra talk about the technology did not occur in the face-to-face groups, and therefore cannot account for the increased dialogue length in the threeperson face-to-face groups. The amount of social talk in the different conditions did not vary. This means that there must be something different about the way groups of three complete the task.

The key lies in the establishment of common ground. When people perform the Map Task, what they say can be divided into subsections according to the landmark that is most significant for the part of the route being completed. For each task-oriented turn, we determined which map landmark was under discussion, and who had information about that landmark on their map. This allowed us to calculate the amount of talk which landmarks generated if they were shared by all participants, known by only one, and so on. The landmarks that generated the extra discussion in the three-person groups were those known by one instruction giver and not the other.

This result is surprising because the task does not require both instruction givers to understand how the route relates to every landmark. As long as the person who has to draw the route knows what to do, the task can be completed successfully. These groups were establishing common ground for all the group members even when they did not need to. This suggests that in three-person groups, the norm is to aim for complete mutual understanding, just as in dialogue.

4.4. Exploratory study: virtual teams

Communication technologies are in widespread use in modern organizations, but make monitoring, and therefore grounding, more difficult. Although communication technologies have been widely studied, the newer ones have mostly been observed in relatively favourable settings, such as the offices of the research laboratories developing them (e.g., Dourish, Allen, Bellotti, & Henderson, 1996; Isaacs & Tang, 1997). Other settings are likely to be more hostile, since the prospective users have no inherent interest in the technology and since technical support will be harder to obtain. For this reason, we set out simply to observe the use of one promising technology, multimedia desktop conferencing, in an independent corporate setting. In this study (Carletta, McEwan, & Anderson, 1998; Carletta, Anderson, & McEwan, 2000), we were fortunate in being able to observe the results of a European $project^2$ that was trialling this technology for supply chain teams in the automotive sector. Car manufacturers assemble cars but they do not make the parts themselves. Good design requires collaboration between manufacturer and parts suppliers within a supply chain team that draws members from all of the companies involved in a particular assembly. Since team members are geographically dispersed in different companies, communication can be difficult. Communication technology therefore holds great promise for these teams.

We observed two supply chain teams using a system that included an audio link, small video relays from each site, a shared whiteboard, shared computer-aided design (CAD), and shared web-based product libraries, all controlled via a 'point-and-click' interface. This technology was designed to contain all of the capabilities that would be needed for joint design, and particularly, for referring to and sketching on existing engineering diagrams during group discussion. This made it somewhat more complicated to set up than less advanced equipment. It was also rather expensive. That meant that in practice, each company in the study had only one computer set up for desktop conferencing. One of the teams had multiple people present at each site, but sharing one access point. In this case, one person sat at the keyboard of the

² TEAM, project AC070 of the European Commission ACTS Programme (DGXIII), to whom we are grateful for allowing observation of their trials.

computer, with the other participants behind him or to one side. The other team instead chose to meet with only two people at a time.

Although the second team was able to use the technology successfully, the first team's discussions were adversely affected by the choice of technology. This is because it was difficult for the team members who were not sitting at keyboards to participate. Most of the communication over the link was squeezed through a dialogue between the people at the keyboards, as shown in figure 2. Despite good audio and video conditions, the peripheral participants often resorted to giving information to the person at the keyboard so that they would repeat it to the other site. In attempts to widen the conversation, peripheral participants were explicitly addressed by name more often than the central ones. In addition to this disruption to free turn-taking, the talk in the meeting was more formal and less sociable than in a similar face-to-face one which was also observed. Attempts by the supplier to initiate social conversations during breaks in the meeting — an important part of cementing corporate relations and overcoming status differences — went unheeded because the person at the keyboard was too busy to talk, but blocked the others' view.





*Lines connecting participants show primary channels of communication.

The "keyboard squeeze" effect arising from the choice of technology did produce one potentially useful feature — at the supplier end, because a relatively low status participant was the only one who had been trained to use the equipment, he sat at the controls. This made him speak more often than he ordinarily would, which ought to be good for group decision-making. Of course, as users become more accustomed to the equipment, this advantage would probably be eroded; if they are capable of doing so, high status participants are likely to assume control. Meanwhile, the advanced features of the technology that had forced the restricted access went unused because no one at the companies had time to prepare materials for electronic sharing. Any technology that adds to the burden of preparing for meetings is likely to degrade

performance. In this case, the users concluded that the advanced capabilities were not useful, but simpler technology could have been placed on their own desktop machines, eliminating the need to share equipment in the first place.

4.5. Verification of the "keyboard squeeze" effect

If the "keyboard squeeze" effect arising out of our exploratory study of virtual teams applies more generally, this has important ramifications for deployment of communication technologies that are currently being developed. Since free interaction is needed for group decision-making, it is important to know when technologies privilege communication for particular pairs or subgroups. For this reason, we further tested this effect in a laboratory setting using a simulation that preserved the basic setting of supply chain teams, but better controlled whether the team members had individual or shared control of the equipment.

In this study, engineers who were familiar with supply chain relationships took part in a role-playing exercise in which they pretended to be supply chain teams holding a meeting using the same technology as in the previous study. Teams were asked to complete a design task adapted from a real event. In the shared control condition, eight teams varied in size from four to seven members. These teams had one access point for each of two companies representing the manufacturer and a first tier supplier to this manufacturer, with two to four team members per access point. In the individual control condition, there were six three-member teams. Each of the team members used their own access point and represented a different company in the supply chain team: the car manufacturer, a first tier supplier, and a second tier supplier to this supplier. In keeping with the conditions for real companies, the individual representing the second tier supplier was given less sophisticated technology. Video was unavailable, and the audio connection was reduced to poorer sound quality under half duplex (i.e., "click to talk") transmission.

When we compared the amount of talk in the two conditions, we found that the teams with shared control talked more, but that the amount of talk across the interface to the other sites was the same. That is, team members from the same site talked among themselves when they could, but whether they were alone or not did not affect how much was said to the other sites. In the shared control condition, all participants talked the same amount in the local conversations, but the people sitting at the keyboard said the most when the interface was being used. Although all participants contributed to conversations using the interface, especially during the more social sections, the ones at the keyboard dominated in exchanging information essential to the task or in direct problem solving. In the individual control condition, of course, there were no local conversations. In the talk across the interface, the second tier supplier contributed less than the other two companies, and particularly failed to engage in direct problem solving. Despite their impoverished access, however, second tier suppliers still contributed to discussion across the interface on average twice as often as the participants who had better quality access points but were not sitting at the keyboard, in direct control of the equipment.

This study confirmed the basic "keyboard squeeze" effect suggested by our initial field study: when people share an access point within a technology-mediated discussion, those who are directly in control of the access point dominate the

proceedings. If companies wish to encourage true teamworking and group decisionmaking, then it would be best to have enough access points at convenient locations for each team member to use a different one, even if that means worse quality facilities overall.

4.6. Exploration of status effects during audio-conferencing

Most existing studies investigating the use of communication technology in statusdifferentiated groups suggest that technology-mediation is a way of reducing status effects (Dubrovsky, Kiesler, & Sethna, 1991; Kiesler & Sproull, 1992; Silver, Cohen, & Crutchfield, 1994). Our studies suggest that this may not always be the case. If a technology requires shared access but no special skill to operate, then, as we suggested based on our observations of virtual supply chain teams, it is likely to be controlled by the highest status participants, disadvantaging the others even more than usual. Meanwhile, low status participants are likely to have relatively impoverished technology, but this will further reduce their participation, as we explored in our virtual team simulation.

The question of whether technology-mediation makes it easier or harder to establish ground that is common to all group members is an important one. Group decision-making is recognized to be difficult enough that technologists are currently trying to support it through the development of group decision-support systems, or GDSS (Nunamaker Jr., 1997). If some kinds of technology-mediation exacerbate status differences, then such systems may inadvertently push groups away from consensus-forming and back towards a process in which the highest status person makes decisions in consultation with other group members. The usual explanation given for the benefits of technology-mediation is that the technology reduces social presence and cues to status, making lower status participants less inhibited about participating fully (e.g., Kiesler & Sproull, 1992). If this is the case, there could be interesting differences between the text-based forms of mediation used in previous studies and the video-mediation that we employed, where social presence is greater and status cues can be read off the video image.

In order to further explore the interaction between technology-mediation and status, we engaged in a further field study (France, Anderson, & Gardner, 2001), this time involving audio-conferencing. Audio-conferencing is commonly used as a substitute for face-to-face meetings, and so is of industrial importance, as well as occupying an interesting point halfway between the monitoring affordances of video- and text-conferencing, for which the availability of status cues is unclear. In this study, we observed six face-to-face meetings and four audio-graphic PC conferences in which the participants, employees of a large UK telecommunications company, used BT's Conference Call Presence[™] application. This is similar to standard audio-conferencing, but with file transfer, shared whiteboard, and application sharing capabilities on a desktop PC. In two of the four audio-conferences, some participants shared a PC and used a loudspeaker telephone. In the other two, each participant worked from his own machine. Meetings were chosen to all require the same kind of interaction; most were team review meetings. Meetings varied in size from four to eight participants and contained mixed status participants.

What we found suggested that, rather than ameliorating the effect of status differences on group discussion, this form of technology-mediation exacerbates it. For these purposes, a rough score for participant status was constructed by counting the number of levels in the company's organizational hierarchy between the individual and the company chairperson. In four of the six face-to-face meetings, the highest status person dominated the discussion, saying more words and making more contributions than anyone else. Usually they also were involved in more pairwise conversations during the discussion, and initiated more of these pairwise conversations by making the first move in them, than anyone else. However, in all of the audio-conferences, the highest status person present always dominated on all of these measures. In faceto-face meetings, the highest status person contributed on average twice as many words and 1.75 times as many turns as the average participant; for the audioconferences, the highest status speaker was roughly twice as dominant, contributing 4 times as many words and 3.5 times as many turns. Similarly, in audio-conferences the highest status participant was able to engage in and initiate 1.5 times as many of the pairwise conversations that took place. Although statistical comparisons attempting to show that these dominance scores are higher in audio-conferencing than in face-to-face meetings give results of only marginal significance, this is all one could expect with a sample size of ten meetings.

If these results apply more generally for the richer forms of communication mediation, then this has important ramifications for the support of group discussion. When high status participants are able to dominate discussions, this stands in the way of establishing ground that is common for all participants. The high status members are best placed to synthesize the information presented in the discussion, biasing the group towards consultative decision-making. To the extent to which mediating technologies increase the dominance of high status group members, they stand in the way of true group decision-making.

4.7. Organizational division, communication, and performance

One weakness of our field study approach is that it leaves implicit the link between communication process, decision-making, and performance. Field observation makes it difficult to argue that there are real, quantifiable effects of discussion structure on group outcomes. Because of this, we have used broader-brush techniques to test the relationship between overall communication practice and performance in a sample of primary health care teams (Borrill et al., 2001; Carletta & Borrill, in preparation).

In the United Kingdom, primary health care practices are small businesses, usually owned by general practitioners who employ other staff such as a manager, nurses, receptionists, and secretaries. Local health authorities additionally employ staff — typically advanced nurses with a focus on preventative care — who are based in the premises of one or more practices but outside their direct control. The practice employees and "attached" staff together make up a primary health care team.

Primary health care teams are interesting to study because all disciplines must coordinate if they are to provide effective care. At the same time, the team circumstances produce many institutional obstacles to good communication. Since general practitioners both own the business and have the most clinical training, their high status within the team is unquestionable. As we have seen, this can inhibit

communication upwards from their staff. In addition, attached staff are often away from the practice premises and have their own goals external to those of the team.

In this study, we interviewed 80 primary health care team managers about their teams, including their communication practices. This included detailed information about what sorts of meetings the team held, which team members were expected to attend, how often they were held, and how long they took. From this information, we were able to construct measures of the amount of communication that took place in the practice overall, the amount of communication between doctors and practice nurses, and the amount of communication between doctors and attached staff. Although teams did communicate outside meetings, their opportunities were rare. Thus our communication measures should reflect overall practice with reasonable accuracy. In addition to these practice manager interviews, we also asked all team members to fill in a questionnaire designed to test perceptions about team effectiveness and team working (Anderson & West, 1994; Carter & West, 1998; Poulton & West, 1993).

We found that despite the importance of good communication, one-third of teams held no meetings that combined attached and practice staff. For another third of the teams, the only contact between attached and practice staff came in "whole team" meetings that everyone was expected to attend and whose remit was rather vague. Although team size is an important factor in determining communication needs, there was no relationship between what sorts of meetings the teams held and size, except that teams which held "whole" team meetings and nothing else tended to be relatively small. This suggests that larger teams may not be particularly effective at devising practices to fit their circumstances.

This possible problem for large teams carries over into what the team members think of their own effectiveness. In small teams, there is no relationship between communication practice and self-reported effectiveness. However, in large teams, team members report that they provide more professional delivery of care and work together better when there is more communication between doctors and attached staff on the team, and to a lesser extent also between doctors and practice nurses. Despite this, their perceptions of how they are doing are not correlated with the amount of communication in the team overall.

This study suggests that how well teams overcome the factors that make it difficult for team members to understand each other — group size, status differences, and organizational divisions — will affect how well they perform. Since the study is small and thus results in relatively weak correlations, relies on self-reporting for its effectiveness measures, and ignores other variables such as social deprivation in the population served which must impact team outcomes, it is no more than suggestive. However, simply the fact that we are able to find such effects shows the importance of understand the communication processes that operate in work groups.

5. Discussion

Together, our studies argue that group size, status differences, and organizational structures all serve to make it more difficult for groups to engage in free and active discussion, and therefore to perform group decision-making, whether they meet face-to-face, use communication technology, or fail to meet at all.

At least small group discussion appears to employ a straightforward extension of the grounding processes that are well understood from previous work on dialogue. Face-to-face groups up to size seven behave like pairs of speakers with overhearers. Just as dialogue participants try to mutually understand each other, establishing common ground among all members of a group appears to be a normal way of operating. At least, groups of three attempt to establish common ground even in cases where this is unnecessary to the task they are completing.

Despite this analysis for small groups, there is some evidence of a sudden change of process at size eight groups to a less dialogic model. In these larger groups, speakers broadcast their contributions to the group as a whole rather than interacting with another individual in the group. This gives everyone an equal chance to understand each contribution, but privileges those group members who speak the most.

Teamworking and group decision-making rely on the establishment of common ground across all group members. However, it is remarkably easy to disrupt this process. In status-differentiated groups, higher status members have the advantage. Any group which has one member in a position of authority over the others will have a discussion structure that makes him more prominent, privileging his point of view. In large group discussions, such a leader will emerge whether or not one has been appointed. Organizational structures that cut across the group membership tend to reduce the opportunities for communication across the divide. Communication technologies, in widespread use, can clumsily privilege some channels of communication within the group whilst blocking others, distorting which group members understand each other. All of these factors operate in a complex interplay to disrupt the work of teams by privileging some of the communication unfairly— but unbalanced group communication can have a traceable effect on group outcomes.

6. Future work

Of course, our work to date has merely provided a descriptive overview of some of the factors affecting communication and decision-making in work groups. At this stage in the research cycle, we have enough conjectures gleaned from observations of real groups, so we are concentrating on laboratory studies to verify our current theories, both for face-to-face and mediated groups.

Our priority is to produce further evidence of the essential differences between small and large groups, and to verify that there is a model split, as we have suggested, between size seven and size eight. In order to do this, we must establish that small groups up to size seven try to establish common ground in the usual fashion for dialogues, so that small group discussions can be seen as dialogue with process loss due to the difficulties of fully understanding material which is merely overheard. Meanwhile, for the larger groups, we need to show that this dialogue-based model is inappropriate, and that instead speakers behave as if they are broadcasting their utterances to the entire group. Our approach to this research goal is three-pronged, consisting of a comparison of discussion structure in the different size groups, analyses of information flow and grounding, and an investigation into how the role of gaze in turn-taking might explain the need for different models.

Proving our theories requires new types of data, especially since eye contact affordances play a critical role in our thinking about these effects. We have been

working on two new types of sources. The first is a more complete recording of plagiarism task trials such as that reported in section 4.2 in which kinesics are available for study. Careful thought is required to design data capture for groups. Although the high-tech approach would be to employ multiple video streams, for the larger groups this would require us to synchronize the output of a dozen or so cameras. Such a set-up would be obtrusive, unwieldy, and expensive. Instead, we have conducted pilot recordings that use an overhead camera and baseball caps marked with arrows to capture the essential information from above. We have also piloted a version of the Map Task for three to six participants in which there are no instruction givers and instruction followers, but everyone has an incomplete route. The design ensures that at every point, there are two participants who have the crucial knowledge for the next part of the route, making it possible not only to employ the grounding analysis of section 4.3 but also to determine whether speaking recency affects which potential informant actually contributes.

Our work raises a number of other research topics which, although they are less of a personal priority for us, are still interesting and important. Our original work with manufacturing teams suggested that no matter how small the group, if one person is in overall authority, this impedes free discussion. Groups with a "manager" produce the kind of communication pattern most conducive to consultative decision-making even when they are small. Confirming this would, once again, require new laboratory materials. We see two options here. One is to introduce a variant of the plagiarism study in which one of the participants is in authority — a purported member of academic staff who will be reporting the group's discussion to the University Senate, for instance. The other is to adapt existing studies from social psychology regarding status. These have a group of participants complete a task in which status is evident from the roles individuals are playing. One risk is that such tasks are too simplistic to produce realistic status effects, but in conjunction with naturalistic observations they may help to elucidate the effects of status difference on small group discussion.

Our emphasis on the role of eye contact in face-to-face and video-mediated groups suggests a fascinating but unproven conjecture for status differences, too: it could be that eye contact provides a purely mechanical explanation for some of the effects which we and others have observed. Perhaps people avert their eyes when communicating face-to-face with their superiors, making it more difficult for them to take turns. In addition, it would be natural to monitor high-status participants at meetings more than the others, in order to judge their reactions both to one's own speech and to the discussion in general. Text-based communication, as we have pointed out, has been observed to level status differences. This could be tested using the same sort of recording set-up as our proposed group size studies. Although eye contact cannot be the only mechanism by which relative status affects communication because we have observed effects in audio-conferencing, if our conjecture is true then it is important to understand that.

In more application-oriented research, emerging communication technologies provide excellent opportunities to test out the ramifications of our theories. For instance, some new video-conferencing technologies provide life-size personal images for which gaze direction is clearly discernible. Our work would predict that this sort of technology would be more acceptable for free discussion than any of its predecessors. Alternatively, several vendors are considering systems in which animated avatars

replace the video stream in a bid to reduce the bandwidth required. This technology admits experimentation about exactly what information is needed to smooth group turn-taking.

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