Collaborating Across Cultural and Technological Boundaries: Team Culture and Information Use in a Map Navigation Task

E. Ilana Diamant
University of Pittsburgh
209 Mervis Hall
Pittsburgh, PA 15260
eid3@pitt.edu
(734) 846-0648

Susan R. Fussell
Cornell University
332 Kennedy Hall
Ithaca, NY 14853
sfussell@cornell.edu
(607) 255-1581

Fen-ly Lo
Carnegie Mellon University
5000 Forbes Ave.
Pittsburgh, PA 15213
fenlyl@cmu.edu

ABSTRACT
The increased globalization of the workplace and the availability of collaboration technologies are making CMC a necessary aspect of teamwork [27]. Culturally diverse teams are becoming the norm in knowledge-intensive projects that involve making sense of incomplete, ambiguous, and complex information (e.g., software development, new product design, customer service). The ability of teams to perform such tasks effectively is often a function of the media they use to collaborate and the culturally conditioned expectations of team members. We conducted a laboratory study to examine how different collaboration media and cultural backgrounds influence the sense-making process of culturally mixed and homogenous dyads. American, Chinese, and intercultural American-Chinese pairs of participants collaborated on two map navigation tasks using one of three technologies: video, audio, or IM. As predicted, culture and media interacted to affect the content and pattern of participants' communication.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Human factors.

Author Keywords
CSCW, distributed work, empirical studies, intellectual teamwork, cross-cultural communication.

IWIC'09, February 20–21, 2009, Palo Alto, California, USA.

INTRODUCTION
Cross cultural collaborations that take place in virtual settings face numerous challenges such as different communication styles of participants, difficulty establishing common ground, individuals' differing interpretations of the task and of their partner's actions, and the technology's constraints on team interactions ([6], [21], [30]). Besides affecting task outcomes, those challenges often have second-order effects on the nature of the interaction among collaborators ([38], [20], [39] [24]). Those collaboration challenges stem largely from the reduced social and contextual cues that can be communicated with different technologies ([39], [24]), the distributed nature of the task [6], and the cognitive demands that the technology places on the ability of users to attend to both task-related and social information while working with a partner [20].

People with different cultural backgrounds tend to use collaboration technologies differently; that has been observed in both in field studies and laboratory experiments (35], [29], [23]). For example, Setlock et al. [35] found that Chinese participants used IM differently from Americans in terms of conversational content, efficiency, and task performance. Massey et al. [29] examined differences in satisfaction with asynchronous communication across individualist and collectivist cultures. Lack of prompt feedback and reduced contextual cues were associated with lower satisfaction levels among participants having a collectivist background.

In a recent study [10], we examined the joint effect of culture and media in individuals' attribution for the performance of their team. American, Chinese, and intercultural American-Chinese student pairs collaborated on two map navigation tasks using one of three technologies: video, audio, or IM. Attribution theory states that people make different decisions about the causes of events, such as their team's performance on a task, if they have different kinds of cues about their partners (e.g., different visibility of their partner's actions during the task [6]). Poor team performance, for example, might be attributed to a partner's personality or lack of interest

(dispositional attributions) or to technical problems and to task difficulty (situational attributions).

Our analysis had shown that culture and technology interacted to affect the extent to which members attributed team performance to dispositional factors (e.g., personality or mood) vs. situational factors (e.g., the technology or task difficulty). More specifically, we had found that the greater visibility of partners in the video condition reinforced the tendency of American participants to make more dispositional attributions in video and fewer dispositional attributions in the audio condition. For Chinese participants, greater visibility of their partner did not significantly alter their attributions, which were equally situational in both video and audio conditions.

In IM, the absence of visual and auditory cues in IM reversed the attribution biases for both cultural groups: Americans made mostly situational attributions whereas Chinese made mostly dispositional attributions in IM. Moreover, attributions did not differ depending upon the culture of a person's teammate. Neither Americans nor Chinese participants perceived culturally similar partners more favorably than they did culturally dissimilar partners, despite the fact that performance in cross-cultural teams was worse than in same-culture teams

Those results, however, left open some questions about how team members communicated in the course of doing the task. Conversations often included misunderstandings, lack of feedback, confusion about the maps, and frustration with the other person, as shown in the example below:

Instruction Giver	from Sandy shore go north alone weill then you will meet hills, then around hill, you go north go straight turn right, go through iron bridge, go ahead you will see wood, cross wood go alone forked stream, turn left and you will across farmed land, you will see dead tree turn left, go ahead until you meet pine tree,
Follower	i don't understand- what does "north alone weill" mean?
Follower	also, my map doesn't have directions like north or south- is north towards the hills on your map?
Follower	can you start from the beginning and give me the directions one at a time?
Instruction Giver	go around pine grove, go North until you meet farmed land, turn left, and across lagoon, turn right, go north west, you will meet crab island, go around crab island, you will meet rock fall, go South, you will see conputer controlled sub, croos it, turn left, you will see your destinatin - pirateship
Follower	can you start at the beginning and send me the directions one part at a time?
Follower	I DO NOT UNDERSTAND- PLEASE Send me the first step in the instructions again!
Follower	HELLO?????

In this example we see that the miscommunication between the instruction giver and follower involved an expectation or preference on the part of the follower to receive instructions one step at a time while the instruction giver expected the follower to interpret the instructions without feedback and clarifications. The giver (wrongly) assumed that the follower had the same landmarks on his or her map, and that navigation could be done just by following a series of explicit instructions.

To examine whether this example of miscommunication and the expectations underlying it are influenced by individuals' cultural backgrounds and/or the media they used, we posed the following questions: First, how do the communication patterns of same-culture vs. different-culture teams differ across media? Second, how do different communication media affect the teams' ability to make sense of incomplete and disparate information they have about the task? To answer these questions, we examined differences in the communication patterns of dyads having different cultural configurations (AA, AC, CC) and whether the communication patterns across media and cultures explained differences in participants' attributions.

Prior studies have compared some form of virtual teamwork against face-to-face collaboration (with a few exceptions, e.g., [43], [20]). To examine the role of virtual collaboration in a systematic manner, we need to look inside the various ways in which team is "virtual", and identify effects of different virtual conditions by comparing them against each other rather than just against face-to-face conditions. In this study, we differentiate between teams collaborating via three technologies (video, audio, instant messaging [IM]). Also, we assess culture as both an individual difference and as a team characteristic to distinguish its effects at both levels of analysis.

We conducted a laboratory study in which 95 dyads of participants performed two collaborative map navigation tasks in one of three media (audio conferencing, video conferencing, IM). Dyads were constructed to form three team culture conditions (homogenous-American, homogenous-Chinese, American-Chinese).

Collaborative Sense Making

Navigating a map becomes challenging when the person giving and the person following directions have different information about the targets they need to reach (e.g., different landmarks on their maps). In order to make sense of the maps, the instruction giver and follower need to identify which landmarks are the same vs. different in their maps, formulate instructions, and give feedback in a way that is helpful to somebody whose map has different landmarks. Navigating a map with a partner can be thought of as a collaborative sense-making task. Sense-making has been described as a search and matching process: people search for external representations of a target (e.g., a landmark on a map) based on available information and identify the intended target by matching the available information to the task features [34]. For example, a person following directions in a map would use the information given by his or her partner to search for a landmark on the

map; he or she would identify the presumed target by comparing the partner's description to the landmarks on his/her own map and find the one that best matches the given description.

Moreover, collaborative sense-making involves multiple actors with different views about the world trying to understand disparate or unstructured information [14]. Individuals' beliefs and values, as well as the dynamics of the interaction often affect the way teams make sense of the information they have about their task. For sense-making to unfold smoothly, without misunderstandings and errors, individuals need to be able to convey information about the specifics of their location on the map and also infer their partner's location from the information their partner shares with them. The ability to convey situational information is at the core of the sense-making process; when people have disparate task representations (disparate maps), incomplete information about their partner's position and movement, and their ability to communicate is limited by a given medium, then the sense-making process can break down easily. These miscommunications become harder to repair the more breakdowns there are in understanding.

Collaborative tasks involve assumptions about the type and amount of information that should be communicated to their collaborating partner, as well as structuring and pacing the interaction so that partners can coordinate the exchange of information in an effective manner. Assumptions and expectations about what information should be communicated and what information the other person needs to do their part of the task are influenced by one's cultural background.

Media Effects

A team's ability to maintain shared situational awareness and make sense of its task depends on members' noticing their partners' difficulty or confusion with the task and on their ability to identify, negotiate and resolve discrepancies in their maps in a timely manner. Collaborating partners with different information about the task maintain awareness of each other's actions by establishing common references to shared objects (e.g., [15]). Being able to communicate visually with one's partner enables a person to readily recognize when that partner is making a wrong turn, does not understand an instruction, or is confused about the task [4]. By observing the partner's gaze and actions, one can adjust his or her communication (linguistic expressions) and their own actions; the ability to do that reduces the effort both people need to put into the task [5].

Collaboration technologies reduce contextual cues in comparison to face-to-face interaction (cf. [24]), some more so than others. For example, video conferencing systems can provide views of facial expressions (e.g., [11]) and/or work areas (e.g., [25]) that may help partners be aware of each others' progress on the task by allowing them to convey signals about problems as soon as they arise. Media that provide visual feedback, such as video conferencing, facilitate the communication of situational and contextual cues between partners, whereas less 'rich' media that lack a visual functionality, such as audio conferencing and IM, make it harder for people to establish and maintain mutual awareness of each other's actions during the task. Because of the visual channel that is available to those collaborating over video conferencing, we anticipated that participants in video will rely less on verbal communication to maintain situational awareness; that is, they would use fewer situational phrases than in audio, which would be greater than in IM. Those collaborating over IM would need to use the most situational phrases because they lack the visual and auditory channels that enable people to notice misunderstandings, wrong turns and provide immediate feedback to repair them.

H1a: Instruction-Givers will use a greater proportion of their conversation to maintain situational awareness in IM than in Audio than in Video.

H1b: Instruction-Followers will use a greater proportion of their conversation to maintain situational awareness in IM than in Audio than in Video.

Culture effects

People with similar cultural backgrounds approach a task with a shared set of assumptions and expectations about how to coordinate the task that are grounded on their similarity of cultural backgrounds. Same-culture teams, having shared assumptions and expectations to guide members' behavior, will be more effective and efficient in making sense of their task than culturally mixed teams. Cultural background in this sense serves as a social resource that can be useful for making sense of a task if it is shared among team members.

Studies of cross-cultural communication have shown that communication patterns among members of different cultures are influenced by the cultural norms, attitudes and the use of language by members of those cultures (e.g., [1], [16]). Individuals with a Chinese vs. an American background can be thought of as members of two speech communities, having different assumptions and expectations about how communication should unfold [17]. High vs. low context refers to the culturally conditioned preference for and use of contextual information in communication. Contextual information includes paralinguistic cues, facial expressions, gestures, or any information about the speaker's situation, attitude and behavior. People from high-context cultures such as that of the People's Republic of China, tend to rely on contextual information to interpret a message or to make sense of a communication interaction. People from low-context cultures, such as that of the United States, tend to communicate without including situational and contextual background information about the message they are attempting to convey. On the receiver's end, people from

low context cultures tend to make sense of a message by relying on what has been conveyed explicitly with little reliance on contextual cues around the message or the interaction. People from a high context culture initiating a conversation tends to expect that the listener will infer the meaning of their message from the context of the message more so than from the explicit words that comprise a message. People from a low context culture initiating a conversation will have few expectations from the listener and would attempt instead to convey as much information explicitly related to the task as possible. Accordingly, we expected that:

H2: Chinese Instruction-Givers and Instruction-Followers will use a greater proportion of their conversation to maintain situational awareness than American Instruction-Givers and Instruction-Followers.

Interactive Effect of Culture and Media

Establishing situational awareness is more challenging for culturally diverse teams because they have different expectations and assumptions about how the task can be best coordinated and how the collaborative process should unfold [35]. Moreover, the communication medium that teams use to share task-related information often places constraints on their ability to build common ground, to be aware of the disparate information each person has and to identify what information needs to be shared, when it is needed, and at what point in the collaboration it should be shared ([30, 28]). As discussed earlier, media without visual capabilities place additional constraints on the sharing of situational information. Building common ground and maintaining awareness over IM is harder than over audio and video because participants lack the additional auditory and visual channel and instead need to compensate and use more situational phrases in their conversation to build common ground. Cultural differences will compound that effect: participants collaborating with a culturally dissimilar partner will use more situational phrases to maintain awareness and build common ground when the medium they are using to collaborate is IM than audio than video. Participants collaborating with a culturally similar partner will use fewer situational phrases because their common cultural background provides them a form of common ground and set of shared assumptions about the process of collaboration.

H3a: Participants working with a culturally dissimilar partner will use more situational phrases in IM than in Audio than in Video.

H3b: Participants working with a culturally similar partner will use fewer situational phrases in IM than in Audio than in Video.

METHOD

Overview

We tested the hypotheses in a lab experiment in which culturally mixed and same-culture dyads performed two map navigation tasks using one of three technologies: video conferencing, audio conferencing, or IM. One third of the pairs was comprised of two U.S. citizens, one third was comprised of two citizens of the People's Republic of China or Taiwan, and one third was comprised of one American and one Chinese member. After completing each map, pairs completed a post-task survey in which they rated their task effort and possible causes of their team's performance. At the end of the experiment, participants completed a final survey in which they provided demographic information, completed a personality inventory, rated the technology they used to communicate, and rated their partners on several dimensions. Objective performance was calculated by assessing deviations between the instruction-giver's route and the route drawn by the instruction-follower.

Participants

Participants consisted of 190 students at a U.S. academic institution (92 American; 90 Chinese born and raised in the PRC and 8 in Taiwan). The Chinese participants were all fluent in English but had been in the U.S. for less than 5 years. That minimized the likelihood that their attribution-related predispositions would be substantially affected by the individualist U.S. environment. Participants were assigned either to a partner of the same cultural background or to a partner of the other cultural background, creating three cultural groups: American-American (AA), Chinese-Chinese (CC), and American-Chinese (AC). Pairs were then randomly assigned to one of the three technology conditions (IM, Audio, Video).

Materials

Participants completed two tasks, each of which involved the instruction-giver describing a route on a map to the

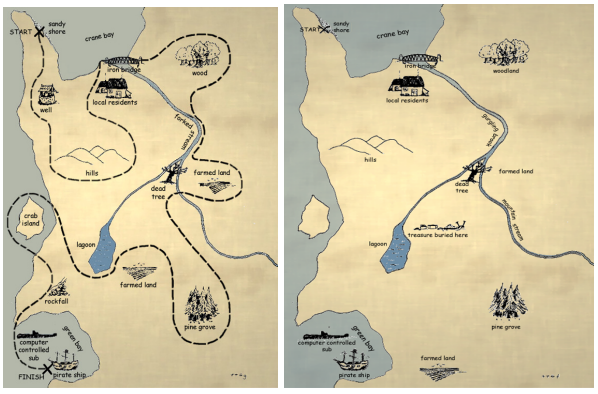

Figure 1. A pair of maps used in the study. The map on the left is for the instruction-giver and indicates the route to be traced. The map on the right is for the instruction-follower and does not indicate the route.

instruction-follower. Each map has two versions, one for the instruction-giver that included the route to be traced, and one for the instruction-follower that did not include the route (see Figure 1). The landmarks on the two maps are not identical, adding challenge to the task. These maps, which we obtained from the HCRC project (www.hcrc.ed.ac.uk) have been used in previous CMC studies (e.g., [11] [45]). Additional materials included post-task and post-experimental surveys containing the questions described below under Measures. These were distributed online.

Equipment

In the video condition, web cameras located above each participant's monitor sent a head and shoulders view of that participant to his/her partner. Video was displayed full-screen on a color 13-inch monitor located directly in front of each participant (see Figure 2). Sony wireless microphones were used to record audio in both conditions.

Figure 2. Arrangement of equipment in the video condition.

Procedure

Participants filled out consent forms and then were seated at computers separated by a large barrier that prevented them from seeing one another. Participants were given their first map and assigned randomly to be either the instruction-giver or the instruction-follower for that (first) task. They were then given instructions about navigating the map, which explicitly stated the goal of the navigation (reach the destination, pass through all the landmarks, complete the task as fast as possible). They then started working on the first map. After finishing the first map they completed a post-task questionnaire to assess their views of how well they coordinated the navigation with their partner, their understanding of the task and the attributions they made about their performance on the task. They then switched roles between Instruction-giver and Instruction-follower and worked on the second map. At the end of the experiment, they completed another questionnaire assessing their ratings of the technology, ease of communication, and perceptions of their partners. They were then provided with further information about the purpose of the study, paid a small fee for their time and dismissed. The materials and conversation were all conducted in English, even for the Chinese/Chinese pairs. This was done to ensure the comparability of data between Chinese in CC and AC teams.

MEASURES

Three sets of dependent measures were collected: post-task survey responses, completed after each of the two map tasks, post-experimental survey responses, collected at the completion of both map tasks, and performance data, extracted from the instruction-followers' maps.

Conversation Analysis

To better understand the differences in the participants' task performance and attributions we analyzed the conversational transcripts of 50% of the sample (48 out of the 95 total of sessions in the sample). The experiment's sessions had been recorded and conversations were transcribed and coded. The coding was done by native English speakers blind to the study's experimental conditions and hypotheses. The mean inter-rater reliability score was 7.5 (higher than the standard threshold of 7.0).

The conversational analysis was done as follows: we identified distinct categories of utterances that structured the participants' conversations during the navigation task, then examined the range of utterances in a session's conversation that could be coded with those categories. That was done in an inductive, iterative manner until a set of categories emerged that were thematically distinct from each other and could be used to code the full range of utterances (below are examples of utterances and their coding).

Table 1. Coding categories used in the study with examples of each. (IG = Instruction Giver, IF = Instruction Follower).

Category	Example
Instructions	IG.: continue south in a snake like pattern and circle around the rocks I.F.: what landmark should i look for next?
Feedback	"ok", "yes", "no", "uhuh"
Situational Awareness	IG.: Do you have crab island [on your map]? IF: No, I don't. Is that uh, that little island off of the… off the coast?
Status reports	IF; I went to farmland already then to lagoon IF: I'm as far east as i can go
Meta-coordination	IG.: can you hear me? IF: Ok I didn't know who was talking over there. IG: Uh ok I'm your instruction giver
Social expressions	IF: OK, good IG: *laugh*, IF: great job

The resulting categories, which we refer to as "message types" exchanged between partners were: *instructions* (giving and receiving navigation directions), *situational awareness* (clarifications and descriptions of landmarks and routes), *feedback* (backchannels such as "yeah" or "uhhuh"), *status* (reports of one's location on the map), *meta-coordination* (discussion of the experiment itself), *social expressions* (greetings, congratulations), and *other* (uncodable or unintelligible utterances. Examples of messages in each category are provided in Table 1.

Utterances containing multiple categories were split into their component categories (e.g., an utterance with two instructions was split into two utterances each being a single instruction). This manner of coding doesn't preserve the turn-taking format of naturally occurring conversations but allows a more consistent and accurate identification of the categories.

Communication Efficiency

We calculated the length of each conversation (one per map) as the total number of single-category phrases in the conversation. For each participant, we calculated the relative frequency or proportion of each category (e.g., number of utterances coded as instructions divided by total number of utterances for that map).

RESULTS

Preliminary Analyses

Preliminary analyses showed that there was no effect of which of the two maps a pair was working on nor of whether it was a pair's first or second trial ($F < 1$, *ns).* These variables were thus left out of subsequent analyses.

There was a main effect of culture on conversation length ($p<0.05$); the number of utterances spoken by both participants in each session was significantly higher for Chinese-Chinese pairs, most likely reflecting greater effort to communicate in a non-native language. The mean number of utterances correlated negatively with the performance scores (route accuracy and whether the map destination was reached; $p<0.01$). On average Chinese-Chinese pairs took longer to navigate the maps and had lower performance scores. Because our interest is in the relative use of the three primary coding categories (instructions, feedback and awareness messages), all subsequent analyses were performed using percentages of messages in these three categories to account for the differences in conversation length between cultures.

An initial analysis of message coding categories indicated that three of the categories were relatively frequent in the conversations: instructions (M = 30% of messages), feedback (M = 29%) and situation awareness (M = 32%). The other categories were of extremely low frequency and many dyads' discussion contained no examples of them. Consequently, the main analysis focused on the effects of culture and communication medium on instructions, feedback and awareness messages.

Main Analysis Model

The effects of individual culture, team cultural diversity and technology on percentage of messages was examined in a 2 (individual culture: American vs. Chinese) by 2 (partner culture: American vs. Chinese) by 3 (medium: IM, Audio, Video) by 3 (message type) hierarchical linear model. Dyad and individual nested within dyad were modeled as random effects. Medium was a dyad level factor, individual culture and partner culture were subject-level factors and message type was an observation-level factor. (Note that in mixed model analyses, the estimation method for degrees of freedom associated with the denominator can produce non-integer values; see [26] for details). Because this five factor model generates a very large number of main effects and interactions, we present only the significant findings below.

Effects of Message Type and Role

As expected, there were no main effects for message type and role (both $F < 1.1$, *ns.*). However, there was a significant Role x Message Type interaction ($F [2, 341.6] = 256.55$, $p < .0001$), shown in Figure 3. Not surprisingly, given the structure of the task, instructional messages accounted for a larger proportion of Instruction Givers' messages (M = .50, SE = .02) than Instruction Followers' messages (M = .11, SE = .02; $t [351.64] = 16.87$, $p < .0001$). Instruction-Followers provided more feedback (M = .48, SE = .02) than Instruction-Givers (M = .11, SE = .02; $t [351.64] = -15.78$, $p < .0001$). There was no difference in how much situation awareness information participants in each role provided.

Effects of Communication Medium

There was a main effect of communication medium, which reflects the fact that each of our three message categories accounted for a slightly smaller proportion of the total messages in IM conversations (M = .28, SE = .004) than in Audio (M = .31, SE = .004) or video (M = .31, SE = .004) conversations.

To test Hypotheses 1a and 1b, we examined how the use of the message categories varied by technology. There was a significant Technology x Message Type interaction ($F [4, 341.6] = 7.26$, $p < .0001$) and a significant three-way interaction between technology, experimental role and message type ($F [4, 341.6] = 5.62$, $p < .001$; Figure 4). Contrary to Hypothesis 1a, Instruction-Givers provided significantly less awareness information in IM than audio ($t [254.17] = 2.34$, $p = .02$) and less awareness in video than IM ($t [363.17] = 1.89$, $p = .06$). Instruction-givers provided significantly more instructions in IM than audio ($t [354.17] = 2.86$, $p < .005$) or video ($t [363.17] = 2.48$, $p = .01$.)

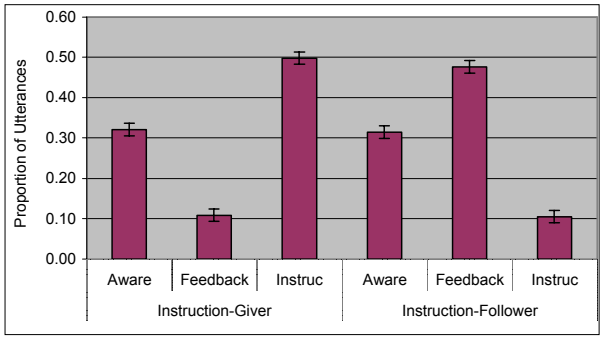

Figure 4: Proportion of awareness, feedback and instruction utterances as a function of medium and experimental role (Giver= Instruction-Giver; Follower = Instruction-Follower).

Somewhat consistent with Hypothesis 1b, Instruction-Followers provided more awareness information in IM than Audio (t [354.17] = 2.20, p = .03 and more awareness in video than audio (t [366.28] = 1.99, p < .05). Instruction-followers also provided more feedback in audio than IM (t [354.17] = 6.56, p < .0001), more in video than IM (t [363.17] = 4.06, p < .0001), and more in audio than video (t [366.28] = 3.01, p < .005.

Effects of Culture

Culture, both of the participant and of his/her partner, shaped the main findings above in a number of ways.

Participant culture shaped the difference in message structure between Instruction-Givers and Instruction-Followers (F [2, 341.6] = 3.14, p < .05). As shown in Figure 5, American Instruction-Givers use more instructions than Chinese Instruction-Givers (t [360.08] = 2.54, p = .01). Contrary to H2, however, there was no interaction between culture and the use of situational messages.

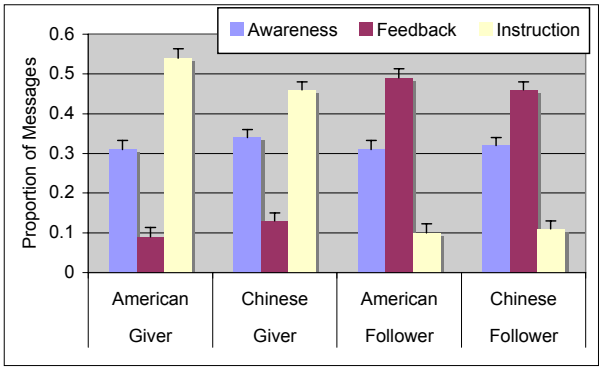

Figure 5. Proportion of awareness, feedback and instructional messages by experimental role and participant cultural background.

Taking into account the communication medium, participant culture had different effects in the video condition depending on the individual's role, culture and the culture of the person one was working with. As is shown in Figures 6 and 7, there was a significant five-way interaction between Individual Culture x Partner culture x Experimental Role x Communication Medium x Message Type (F [4, 341.6] = 3.36, p = .01.)

Figure 6 shows the interaction for Instruction-Givers. American Instruction-Givers tended to provide fewer instructions when speaking to a Chinese partner than to an American partner, and this effect was borderline significant for the video condition (p. < .10). Chinese Instruction Givers in video provided marginally more situational information to Chinese partners than to American partners (p. = 08). No significant effects were found for instruction givers in IM and Audio.

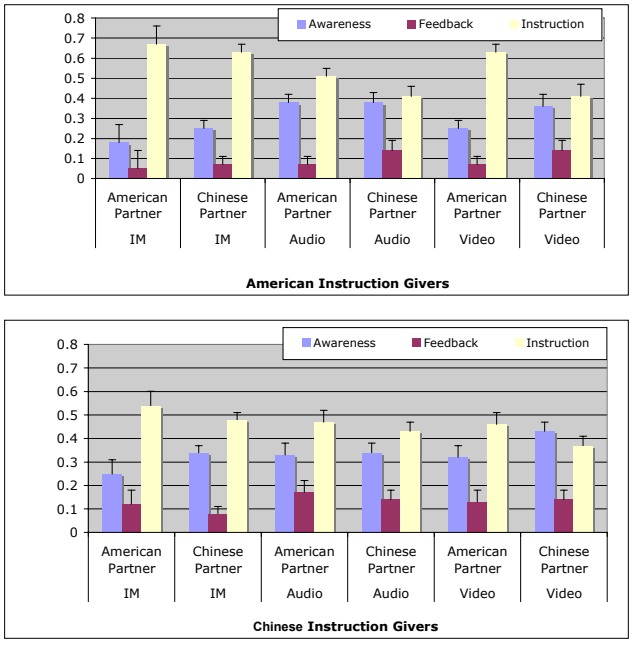

Figure 6. Effects of participant culture, partner culture and communication medium on Instruction-Givers' messages.

Figure 7 shows the interaction for Instruction-Followers. American Instruction Followers provided more situational information in IM than in Video (and marginally more in IM than in audio). Moreover, the amount of situational information they provided was different depending on the culture of the person they were working with. In IM, American followers provided more situational information to American partners than to Chinese partners (p < .05). In audio, the reverse seems to have been the case: they tended to provide more situational information to Chinese partners than to American partners (p < .10). Partner culture didn't have an effect in the video condition.

Chinese Instruction Followers used similar amounts of situational information across media and regardless of their partner's culture. They also used more feedback phrases in audio when talking to an American than to a Chinese partner ($p = .01$).

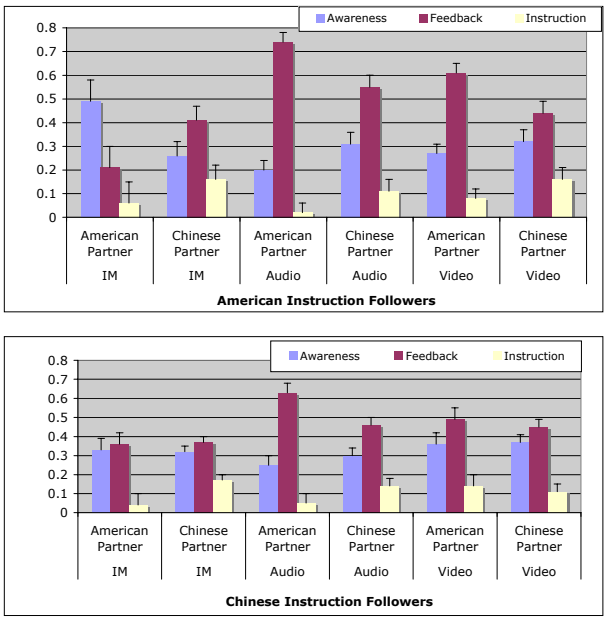

Figure 7. Effects of participant culture, partner culture and communication medium on Instruction-Follower's messages.

DISCUSSION

The findings from our experiment show that different collaboration technologies affected the communication patterns of Chinese vs. American participants in different ways. This work thus extends previous studies (e.g., [35], [36], [45]) by demonstrating that media affect collaboration processes differently depending on the cultural background of their users. Below we discuss these findings and their implications for the design of tools to support cross-cultural collaboration.

Hypotheses 1a and 1b: We had anticipated that IM conversations would include more situational awareness phrases than audio than video, for both Instruction-Givers and Instruction-Followers. Results showed that participants used more situational awareness phrases in IM than in video. Audio, however, had larger proportions of situational awareness phrases than video. A possible explanation for that might be that participants in video did not make the most of the video channel to coordinate the exchange of information about the maps. The video system let them observe their partner's face but did not let them see their partner's map. When there were misunderstandings and confusions about the maps, participants would try to establish mutual gaze over the video screen and then use gestures to indicate the shape and position of landmarks to their partner. Trying to catch their partner's gaze over the screen took extra time and diverted their attention away from the maps so in a sense the visual capability required additional cognitive effort. That additional effort was not possible in the audio condition so people had a small advantage of channeling their effort, gaze, and attention to the maps without having to look up in the screen and attempt to initiate visual communication with their partner. Participants in IM had to use more situational phrases because they had only a text-based channel available. IM lacks the immediacy of feedback that is common in audio and video ([4], [3]) so people were coping with the discrepancies in the maps by exchanging more situational information back and forth until they were able to orient themselves in the maps and identify the correct targets.

Hypothesis 2: Contrary to H2, there was no interaction between participant culture and use of situational messages. Even though Hall's observations predict that Chinese participants rely on contextual information to understand a message or to complete a task, our data do not show any differences in actual use of situational information between Americans and Chinese. Differences emerge only when we consider the interaction of participant's culture and communication medium.

Hypothesis 3: Our most significant findings concern the interactive effect of cultural background and media in shaping communication patterns. Cultural similarity affected the way that American participants communicated with their partners but not the communication patterns of Chinese participants. More specifically, American Instruction-Givers used more instructional phrases when talking to a person of a similar cultural background than when talking to a person of a different cultural background. American instruction-followers provided more situational information to American partners than to Chinese partners. The communication patterns of Chinese participants (whether instruction givers or followers) did not differ based on their partner's cultural background. A possible explanation for that difference is that Chinese participants could adapt to their partner's communication style and behavior more effectively than Americans. This explanation is consistent with Hall's suggestion that people from high-context cultures are better able to adapt their communication style, manner of talk and behavior when communicating with somebody from a low-context culture. Our findings offer preliminary evidence to that end, however further studies are needed to replicate these findings. In addition, this study compared text-based IM communication with video- and audio-communication; the participant's typing skills might have affected their communication ability in IM; further research is needed to determine whether that affects the content of communication in a qualitative manner (as opposed to the amount of words they type).

Our findings also suggest that some of the differences in attributional biases that we observed in our initial analyses [10] might have been due not only to a participant's cultural background but also to that of his or her partner. As mentioned earlier, Chinese participants made fewer situational attributions in IM than in video, and Americans had made more situational attributions in IM than in video. The partner's culture, the type of information exchanged during the task and the participant's role might have jointly affected their attributions. Chinese participants, especially instruction followers, exchanged more situational information with culturally-similar partners, which might have led them to attribute their collaborative performance on the task to the fact that they had more information available. For Americans, on the other hand, the relationship between attributions and partner culture is more complicated: they exchanged less situational information in video when following instructions but not when giving instructions, and more so when their partner was American than Chinese. Nevertheless, this association between partner culture, self culture and attributions is a preliminary observation that partially explains some findings but not others and needs to be replicated in other studies.

Limitations and Future Research

Our results provide initial insights into how communication patterns in a collaborative task are influenced by culture and technology. Nonetheless, the generalizability of the findings is limited by several aspects of our research paradigm: we studied very small teams (dyads), a very limited number of cultures, and a short-term task. Future work will be needed to determine how well these findings generalize to larger teams from a greater diversity of cultures, and to longer-term real-world tasks.

ACKNOWLEDGMENTS

This material is based upon work supported by the National Science Foundation under Grants No. IIS-0803482, IIS-0325047 and CNS-0551554. We thank Anne Anderson for sharing the HCRC map task with us, Leslie Setlock and Hao-Chuan Wang for their comments on earlier drafts of this work, and Hau-yu Wong, David Rush and Ashley Molz for help running the experiment and coding data.

REFERENCES

1. Chang, H.-C., & Holt, G. R. (1991). The concept of *yuan* and Chinese interpersonal relationships. In S. Ting-Toomey & F. Korzenny (Eds.), *Cross-cultural interpersonal communication* (pp. 28-57). Newbury Park, CA: Sage
2. Choi, I., Nisbett, R. E., & Norenzayan, A. (1999). Causal attribution across cultures: Variation and universality. *Psychological Bulletin, 125*, 47-63
3. Clark, H. H. & Brennan, S. E. (1991). Grounding in communication. In L. B. Resnick, R. M. Levine, & S. D. Teasley (Eds.). *Perspectives on socially shared cognition (*pp. 127-149). Washington, DC: APA.
4. Clark, H. H., & Krych, M. A. (2004). Speaking while monitoring addressees for understanding. *Journal of Memory & Language, 50*(1), 62-81.
5. Clark, H. H., & Wilkes-Gibbs, D. (1986). Referring as a collaborative process. *Cognition, 22*, 1-39
6. Cramton, C. D. (2001). The mutual knowledge problem and its consequences for dispersed collaboration. *Organization Science Special Issue*, *12*, 346-371.
7. Cramton, C. D. & Hinds, P. J. (2005). Subgroup dynamics in internationally distributed teams: Ethnocentrism or cross-national learning? *Research in Organizational Behavior,* 26: 231-263
8. Cramton, C.D., Orvis, K., & Wilson, J. (forthcoming) Situation invisibility and attribution in distributed collaborations. *Journal of Management.*
9. Dabbish, L., & Kraut, R.E. Controlling interruptions: Awareness displays and social motivation for coordination. *Proceedings of CSCW 2004*. 182-191.
10. Diamant, E. I., Fussell, S. R. & Lo, F-L. (in press). "Where did we turn wrong?" Unpacking the effects of culture and technology on attributions of team performance. *Proceedings of CSCW 2008.* NY: ACM
11. Doherty-Sneddon, G., Anderson, A. H., O'Malley, C., Langton, S., Garrod, S. & Bruce, V. (1997). Face-to-face and video mediated communication: a comparison of dialogue structure and task performance. *Journal of Experimental Psychology: Applied, 3*, 105-125.
12. Dweck, C. (1999). *Self theories: Their role in motivation, personality and development*. Philadelphia, PA: Psychology Press.
13. Gilbert, D.T. & Malone, P.S. (1995). The correspondence bias. *Psychological Bulletin, 117*, 21-38.
14. Furnas, G.W. and Russell, D.M. Making sense of sensemaking. *Ext. Abstracts CHI 2005*, 2115-2116.
15. Fussell, S. R., & Krauss, R. M. (1992). Coordination of knowledge in communication: Effects of speakers' assumptions about what others know. *Journal of Personality and Social Psychology*, 62, 378-391.
16. Gudykunst, W. B., Matsumoto, Y., Ting-Toomey, S., Nishida, T., Kim, K., & Heyman, S.(1996). The influence of cultural individualism–collectivism, self-construals, and individual values on communication styles across cultures. *Human Communication Research*, 22, 510–543
17. Hall, E. (1976/1981). *Beyond culture*. NY: Doubleday.
18. Hancock, J.T., & Dunham, P.J. (2001). Impression formation in computer-mediated communication revisited: An analysis of the breadth and intensity of impressions. *Communication Research, 28,* 325-347.

19. Hewstone, M., Gale, L., & Purkhardt, N. (1990). Intergroup attributions for success and failure: Group-serving bias and group-serving causal schemata. *European Bulletin of Cognitive Psychology, 10*, 23–44.

20. Hinds, P. (1999). The cognitive and interpersonal costs of video. *Media Psychology*. 1 (33), 283-312.

21. Hinds, P. & Kiesler, S. (Eds.) (2002). *Distributed work.* Cambridge, MA: MIT Press.

22. Hofstede, G. J. (2001). *Culture's consequences: Comparing values, behaviors, institutions, and organizations across nations* (2nd ed.). Sage.

23. Kayan, S., Fussell, S. R., & Setlock, L. D. (2006). Cultural differences in the use of instant messaging in Asia and North America. *Proc. CSCW 2006.*

24. Kiesler, S., Zubrow, D., Moses, A. & Geller, V.(1985). Affect in computer-mediated communication: an experiment in synchronous terminal-to-terminal discussion. *Human-Computer Interaction*, 1, 77-104.

25. Kraut, R. E., Fussell, S. R., & Siegel, J. (2003). Visual information as a conversational resource in collaborative physical tasks. *Human–Computer Interaction, 18,*13–49.

26. Littell, R., Milliken, G. A., Stroup, W. W., & Wolfinger, R. D. (1996). *SAS system for mixed models*. SAS Institute.

27. Malone, T.W. (2004).The future of work: how the new order of business will shape your organization, your management style, and your life. *Harvard Business School Press, Boston, Massachusetts*, 2004

28. Mark, G., & Abrams, S. (2005): Differential interaction and attribution in collocated and distributed large-scale collaboration. *Proceedings of HICSS 2005.*

29. Massey, A., Montoya-Weiss, M., Hung, C. & Ramesh, V. (2001) When culture and style aren't about clothes: Perceptions of task-technology "fit" in global virtual teams. *Proceedings of GROUP 2001* (pp. 207- 213).

30. Olson, G.M. & Olson, J.S. (2000) Distance matters. *Human-Computer Interaction*, 139-178.

31. Pettigrew, T. (1979). The ultimate attribution error: Extending Allport's cognitive analysis of prejudice. *Personality and Social Psychology Bulletin*, 5, 461-476.

32. Rogers, E.M. & Steinfatt, T.M. (1998). *Intercultural Communication*. Waveland Press.

33. Ross, L., & Nisbett, R. E. (1991). *The person and the situation: Perspectives of social psychology*. NY: McGraw Hill.

34. Russell, D.M., Stefik, M.J., Pirolli, P., and Card, S.K. The cost structure of sensemaking. *CHI 1993*, 269-276.

35. Setlock, L. D., Fussell, S. R., & Neuwirth, C. (2004). Taking it out of context: Collaborating within and across cultures in face-to-face settings and via instant messaging. *Proceedings of CSCW 2004* (pp. 604-613).

36. Setlock, L. D., Quinones, P. A., & Fussell, S. R. (2007). Does culture interact with media richness? The effects of audio vs. video conferencing on Chinese and American dyads. *Proceedings of HICSS 2007.*

37. Short, J.A., Williams, E., & Christie, B. (1976). *The social psychology of telecommunications.* NY: Wiley.

38. Sproull, L. & Kiesler, S. (1991). *Connections: New ways of working in the networked organization*. Cambridge, MA: MIT Press.

39. Storck, J., & Sproull, L. (1995). Through a glass darkly: What do people learn in videoconferences? *Human Communication Research*, *22*, 197-219.

40. Straus, S. G., & McGrath, J. E. (1994). Does the medium really matter? The interaction of task type and technology on group performance and member reactions. *Journal of Applied Psychology, 79,* 87-97.

41. Tajfel, H. & Turner, J. C. (1986). The social identity theory of intergroup behavior. In S. Worchel & W. G. Austin (Eds.), *The psychology of Intergroup Relations* (pp. 7-24). Chicago: Nelson-Hall.

42. Tan, B. C. Y.,Wei, K.-K.,Watson, R. T., Clapper, D. L., & McLean, E. R. 1998. Computer-mediated communication and majority influence: Assessing the impact in an individualistic and a collectivistic culture. *Management Science, 44:* 1263–1278.

43. Tanis, M. & Postmes, T. (2003). Social cues and impression formation in CMC. *Journal of Communication, December 2003,* 676-693.

44. Triandis, H. C. (1995). *Individualism and collectivism.* Boulder, CO: Westview Press.

45. Veinott, E., Olson, J., Olson, G. & Fu, X. (1999) Video helps remote work: Speakers who need to negotiate common ground benefit from seeing each other. In *Proceedings of CHI 1999* (pp. 302-309).

46. Walther, J. B.(1996). Computer-mediated communication: Impersonal, interpersonal, and hyperpersonal interaction. *Comm. Research*, *23*, 3-43.

47. Wang, Z. (1994). Group attributional training as an effective approach to human resource development under team work systems. *Ergonomics, 37,* 1137-1144.

48. Zhang, Q.P., Olson, G.M. & Olson, J.S. (2004) Does video matter more for long distance collaborators? *Proceedings of XXVIII International Congress of Psychology*