One Piece at a Time: Why Video-Based Communication is Better for Negotiation and Conflict Resolution

Wei Dong

Applied Cognitive Science Lab, Beckman Institute of Science and Technology and Computer Science
University of Illinois at Urbana-Champaign, 405 N Mathews Avenue, Urbana, IL, 61801, USA
wdong@illinois.edu, wd96@cornell.edu

Wai-Tat Fu

wfu@illinois.edu

ABSTRACT

We compared the effects of three computer mediated communication (CMC) channels (text, audio, and video) on how people performed an appointment-scheduling task. The task involved a grounding and a conflict resolution component. The results showed that video conferencing supported participant dyads in reaching a consensus that had better balanced performance between the dyads only when task difficulty was high and when there were more inherent conflicts in the task. Participants across the three CMC conditions also demonstrated different patterns of conversation dynamics during information exchange and negotiation. Mediation analysis showed that in video-based communication, strategies of exchanging less information at a time predicted higher levels of negotiation, which in turn predicted smaller performance differences in high conflict conditions. The results suggested that the design and use of communication technologies for remote conflict resolution should promote the strategy of exchanging information in small pieces, which could better support subsequent negotiation and foster a sense of fairness.

Author Keywords
Computer mediated communication, collaborative work, conflict resolution, negotiation, information exchange, communication strategy.

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

General Terms
Human Factors; Experimentation.

INTRODUCTION
There has been a long history of research on how features of different CMC channels could impact outcomes of different forms of remote collaborative work [3, 4, 6, 9, 14, 24, 31]. One common reason for collaborators to communicate is to come up with solutions or methods that are acceptable to both parties. More often than not, conflicts arise and it is critical for collaborators to communicate their needs and constraints to resolve these conflicts and reach agreement on certain tasks or problems. Conflict resolution usually demands collaborators to engage in negotiation and to obtain a mutual agreement, which may or may not be the best possible solution to both parties. In other words, one party may need to compromise and accept a solution that may not be optimal for a single party, but perceived to be optimal to both parties. Oftentimes, a sense of "fairness" is more emphasized in a successful negotiation that further facilitates subsequent collaboration. Given that the conflict resolution process often hinges on the effectiveness of communication between two parties, one may expect the communication channel to play a pivotal role in influencing the final outcome of conflict resolution via different communication strategies. A number of studies have been devoted to investigate this process [16, 21, 22, 26, 36]. Although video conferencing is found to be more supportive for conflict resolution in general, it is still unclear how video influences the negotiation and conflict resolution process [8]. To this end, we conducted detailed analysis on conversation dynamics to understand how exactly do patterns of negotiation and conflict resolution differ in different CMC channels.

The current study compared the effects of three common CMC channels (text, audio and video chatting) on an appointment-scheduling task. We were interested in understanding how the underlying variables in the conflict resolution process influence one another. Specifically, we focused on the two processes: *information exchange* to establish common ground and *negotiation* to resolve conflicts. We also examined the *final decision* focusing on the level of fairness in performance between collaborators.

Effects of CMC Channels on Conflict Resolution in Remote Collaborative Work
Although media richness has been identified as one of the most prominent antecedents of performance in distributed collaborative work via different CMC channels [12], the process is far more complicated and no single technology is perfect for conflict resolution in remote cooperative work [22]. A number of factors such as anonymity, uninhibited behavior, task types, culture and other contextual factors could play a role in moderating the effectiveness of CMC channels [1, 4, 6, 30]. Different frameworks have been established to understand the impact of CMC channels on the process of collaboration and conflict resolution.

Effectiveness of Information Exchange when Establishing Common Ground

A prerequisite of successful conflict resolution is to establish a mutual agreement of the possible solution space (i.e., grounding) [10, 11, 19] such that the potential cost-benefit comparison can be assessed among different solutions by each of the collaborators. Therefore, the process through which mutual ground was established during information exchange could have an impact on subsequent negotiation and conflict resolution. Communication methods may influence this process because the cost of information exchange may impact how likely people will exchange their needs and constraints and what strategies they will choose.

It has been found that information exchange can be suppressed and sometimes biased in computer-mediated group interactions compared to face-to-face groups [22, 23]. A fundamental difference between text and audio/video based channels is whether information exchange is done textually or verbally. Owing to the high cost of typing, the effectiveness of information exchange is much lower and the amount of information exchange is found to be much smaller in text-based channels such as emails [26, 34]. In addition, a large amount of non-textual information in both visual and acoustic format (e.g., speech tones, attention and facial expressions) cannot be directly conveyed by the text channel [31].

On the other hand, the existence of text history can serve as a compensation of low effectiveness in text communication because it is a quick reference for collaborators to easily retrieve previously conveyed information. This method of information retrieval is at relatively low cost compared to holding all the information in working memory when communicating through audio/video channels.

Because of these differences, collaborators may adopt different strategies after evaluating the cost and benefit of these CMC channels. These strategies might include the total amount of information they choose to exchange, the amount of information they bring up at each conversation turn, the choice of revealing certain information over another, and the way information is organized during the exchange process. For example, it is possible that collaborators using the text channel might choose a strategy of exchanging as much information as possible at each conversation turn to compensate for the low efficiency of typing. On the other hand, collaborators talking with each other would probably prefer bringing up small chunks of information in each conversation turn since it would be difficult for them to remember and consume a large amount of information all at once due to limitation in working memory capacity [2].

The way different pieces of information and different potential solutions are brought up will then influence how they are discussed during negotiation, which in turn would lead to different outcomes that are either optimal or suboptimal to one or both parties. When a large number of solution candidates are present, collaborators might find it hard to systematically compare and evaluate the pros and cons of every candidate. Whereas negotiation based on one or two solution candidates could be more thorough and efficient. However, this mechanism has not been directly examined as a potential pathway to explain how different CMC channels impact the communication process, which eventually influences the negotiation and final outcomes of conflict resolution.

Social Cognition in Effective Conflict Resolution

Conflict resolution is a demanding task in remote works. Several rounds of conversation exchanges are usually necessary during the negotiation process between the parties before a consensus can be reached. The negotiation process can be less effective due to a lack of social context and a reduced awareness of social presence [24].

Social cues in acoustic and visual format during conversation are also critical for collaborators to make inferences of other parties' preferences and characteristics (e.g., personality, mood and willingness to compromise). Then they can make adjustments to negotiation strategies to persuade other parties to compromise, and eventually maximize individual and/or group performance. Studies have shown that the ability of collaborators to pick up these social cues to achieve successful collaboration in general increases from text to audio and from audio to video channels. Visual cues such as facial expressions, gesture and focus of visual attention available in video conferencing was found to be especially important in complex social tasks [18, 20, 27, 35]. Quality and synchronicity of audio/video streams also play a crucial role in how easily the existing social cues can be picked up during audio/video conferencing [13, 17, 27].

The Current Study

The focus of the current study was to investigate how different CMC channels affect the process of information exchange and negotiation by analyzing collaborators' conversation dynamics during conflict resolution. The primary goal was to investigate some of the key processes as illustrated in Figure 1.
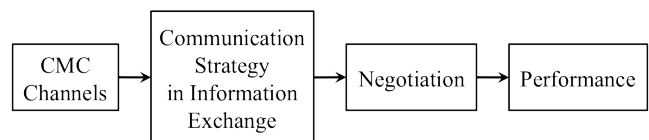

Figure1.The process of conflict resolution to be examined in the current study.

Specifically, we aimed at studying a) how different CMC channels would influence people's choice of different communication strategies when they exchange information to establish mutual ground, b) how the choice of communication strategies would influence subsequent negotiation for achieving mutual agreement on the final decision, and c) whether the negotiation process would affect the performance of collaborators. Mediation analysis,

a statistical analysis method commonly used in social science studies to identify the effects that transmit along a chain of variables [25], was used to examine the effect of CMC channels in influencing the final performance of participant dyads on the task.

We chose the task of appointment scheduling in this study for two reasons. First, it is a very common subtask in most remote collaboration that people encounter in their daily lives, and they often play a pivotal role in the success of collaboration [33]. Second, it involves both the *information exchange* stage in which collaborators need to collectively find one or more time slot(s) that both parties are available, and the *negotiation* stage, in which potential solutions are proposed, evaluated, rejected or accepted, and preferences are expressed and perceived until one solution is eventually accepted by both parties. Although in real situations these two components could be intertwined, they are essential for successful conflict resolution and could be subject to changes in task difficulty (how easily the solution candidates can be found) and levels of conflicts (the amount of overlap between the needs and constraints of the two parties). Thus, we introduced these two independent variables to systematically examine the effect of CMC channels on the process of conflict resolution.

Based on previous studies and frameworks discussed above, we would expect that communication methods with a higher bandwidth (e.g., video condition) would be more supportive for reaching a consensus that optimized the performance of both parties and fostered a sense of fairness between them. Mediation analyses were conducted to reveal the mechanism of why the three CMC channels supported conflict resolution to a different extent. In particular, we would expect that participants using text-based communication would prefer the strategy of laying out a large amount of information at a time to compensate the low speed of typing, whereas participants using audio and video conferencing would prefer bringing up small pieces of information at each conversation turn. We also expect that smaller amount of information exchanged at each conversation turn would better support participants' subsequent negotiation, which in turn would predict the fairness of participant dyads' final performance.[1]

METHOD

A 2 (level of difficulty, within-subject) by 2 (level of conflict, within-subject) by 3 (CMC channels, between-subject) mixed design was employed in the current study. Participants were asked to work in pairs. Each person was

---

[1] We also examined two other aspects in the process of conflict resolution in this study: how participant dyads a) allocated time differently in completing the tasks and b) cognitively navigated through the problem space in different ways when performing the tasks at different difficulty and conflict levels via different CMC channels. Results on these two aspects will not be reported here and can be found in our other article [15].

given a 10-week calendar. Their task was to schedule 2 appointments for each week by communicating with each other via one of the three commonly used *CMC channels* (text, audio or video chatting). A scoring system was introduced to encourage participants to maximize personal scores by scheduling appointments on preferred time slots. We manipulated the *level of difficulty (easy vs. difficult*, as defined later) for each week by putting different score combinations in the solution space. A *level of conflict (low vs. high*, as defined later) was also introduced to further examine the process of negotiation.

Participants

One hundred and four people participated in the current study. Participants were scheduled in pairs and each pair was randomly assigned to one of the three CMC conditions. Participant pairs did not know each other before coming to the experiment. One pair of participants' responses in the text condition and one pair in the audio condition were excluded from the analysis due to technical problems, yielding the final sample size of 100 participants, 17, 16 and 17 pairs in text, audio and video condition, respectively. Participants in the 3 conditions were similar in age ($M = 23.90$, 22.97 and 24.13 years, $SD = 4.45$, 3.25 and 5.15 for text, audio and video condition, respectively, $F_{(2, 97)} = .64$, $p > .05$), gender (16, 13 and 15 males and 18, 19 and 19 females in text, audio and video condition, respectively), education level (college or higher), and their experience of using CMC tools in everyday life as measured in a questionnaire. All participants were daily users of email. In general, participants used Facebook most often for text chatting and Skype most often for audio and video chatting.

Materials

Forty pairs of weekly calendars were prepared. Each week contained a *problem space* of 40 hours (Monday-Friday, 9AM-5PM). Appointments can only be scheduled on whole hours. A scoring system was introduced in a way that participants could earn 0 to 3 points for each appointment depending on when it was scheduled. To help participants better comprehend the scoring system, time slots with higher points were explained as more desired for scheduling appointments in real life situations (see Table 1). Color-coding was also introduced when visualizing the calendars using Google Calendar (See Figure 2).

Time slot	Color	Points
Available, preferred	White	3
Available, but not preferred	Green	2
Not available, but event in this time slot can be rescheduled to make the slot available	Blue	1
Definitely not available, event in this slot cannot be rescheduled	Red	0
Not in the scope of the task	Grey	-

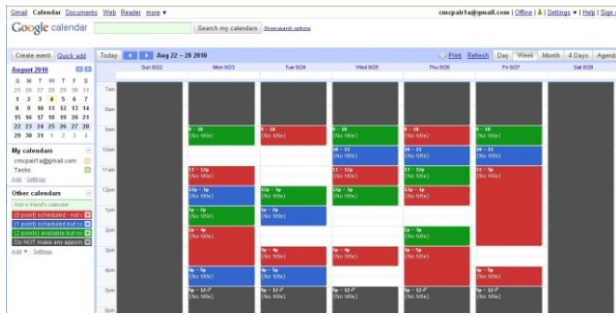**Table 1. Scoring system and color-coding of calendars.**

Figure 2. Example calendar of one week.

Level of Difficulty

Each week had a 12-hour *solution space*. Each appointment scheduled within the solution space would give both sides of the pair a non-zero score. The remaining 28 hours were non-solutions since at least one side of the pair would get 0 points if an appointment was scheduled in those time slots. The level of difficulty for each week was manipulated by varying the number of preferred time slots within the solution space (see Table 2). The 20 easy weeks contained more time slots with high point combinations, whereas the 20 difficult weeks contained more time slots with low point combinations. Thus, the chance of participants finding better potential solutions (with higher points earned by both parties) was higher for easy than difficult weeks.

Solution Space		# of Hours for Each Point Combination	
Point Combination (calendar 1 – calendar 2)		Easy	Difficult
Low	1-1, 1-2, 2-1	1	2
Medium	2-2, 1-3, 3-1	1	1
High	3-3, 3-2, 2-3	2	1

Table 2. Solution space for easy vs. difficult weeks.

Level of Conflict

In order to get participants more engaged and to increase the diversity of possible solutions, several bonus point conditions were introduced (e.g., earning an extra point by avoiding particular hours). After taking all bonus points into account, solutions that would yield the highest total score of the pair were identified. As a result of the introduction of bonus points, the 40 weeks could also be grouped into two groups. In *low-conflict weeks*, only one solution that yielded the highest total score could be identified, thus once such solution was found, neither side of the pair need to compromise. In *high-conflict weeks*, more than one solution that yielded the highest total score could be identified, and each side was able to earn different scores depending on which solution was chosen, thus a process of negotiation was necessary for either side to optimized his/her personal scores. One side of the dyad must compromise in order to reach a decision on high conflict weeks. The level of conflict was not directly manipulated, but identified during the process of examining the solution space of each week. However, the level of conflict was independent of the manipulated level of

difficulty since roughly half of the easy weeks (12) and roughly half of the difficult weeks (11) were grouped into low-conflict weeks, and the rest into high-conflict weeks.

Procedure

Participants were seated at computers in different rooms. Due to limited room availability, several pairs in text condition were separated by large barriers that prevented them from seeing each other. Each pair received a 10-week calendar of 5 easy weeks and 5 difficult weeks randomly chosen from the calendar pool, in random order. Their task was to schedule two 1-hour appointments on two different days for each week; thus, each pair had 20 appointments for the whole experiment. It was emphasized to the participants that their goal was to get their individual score as high as possible, and the three who got the highest individual total scores in all participants would receive an extra $10 as a reward. Maximizing individual score was emphasized to elicit a higher level of conflict and a higher need for negotiation. Participants communicated with each other using Google talk through text, audio or video chatting and marked their scheduled appointments on a printed answer sheet. Participants in the text group could type in text in a box at the bottom of the interface and view the text history above the input box. Chat histories were saved. Participants in the audio and video groups were asked not to type in the chat box and the chat history area will be blank for audio group and replaced by a video stream with their partner's face centered for the video group. Conversations were recorded by screen activity recording software named *SnapzProX*. After scheduling all appointments, participants were asked to fill a short survey, in which they provided basic demographic information and answered questions about their experience of using CMC tools. Participants were then thanked and compensated for their time.

Measures

Performance

Participants' answer sheets were scored based on the scoring system in Table 1. A participant could earn up to 8 points for one week. Participant dyads' *overall performance* was measured by the sum of the scores of the pair averaged across 10 weeks.

Although it was possible that two participants could earn the same score, we did not get any tied pairs in the current experiment. Therefore, for all pairs in this experiment, there was always one person getting a higher total score than the other. We divided each pair into a high-performance side and a low-performance side. A *difference score* was calculated by subtracting the score of the low-performance person from the high-performance person for each week. This difference in performance within each dyad was used not only due to the interdependence in performance within each dyad, but also because this difference score would be more meaningful in measuring the result of negotiation than using individual scores. That is, more balanced scores would be expected as a result of thorough negotiation.

Conversation Dynamics

Participants' conversations during the task were recorded for the text condition and transcribed into text for audio and video conditions. Four coders read the conversations carefully and judged whether each sentence belonged to the following two categories: *time suggestion* and *negotiation*.

Time Suggestion: When a sentence was devoted to either revealing a person's own available time (e.g., I am available Monday afternoon), or asking partner's availability (e.g., would Friday 4 to 5 work for you?), it was categorized into the *time suggestion* category. This category was further divided into two sub-categories. When a person was listing all his/her available time, or asking partner's availability for the whole week, this sentence was categorized into the *condensed-format time suggestion* category. When a person was revealing his/her own or asking partner's availability for a single day or for no more than 2 time slots, this sentence was categorized into the *specific-format time suggestion* category.

Negotiation: When a sentence was devoted to evaluating (or comparing) potential points that could be earned for either or both sides of the dyad (e.g., if I take this green slot, I could also earn 2 bonus points, which is a better choice than taking that white one), or discussing the possibility that either side of the pair would (or would not) compromise by taking a less favored time slot (e.g., would you mind taking a green this time? I will do a green one next week), it was categorized into the *negotiation* category.

Sentences could be coded into both or neither of the two categories. Sentences that did not belong to the above two categories were also coded but were not in the scope of analyses for this article. Four native English speakers went through the training session, during which they were given feedback on their coding to ensure they achieved similar understanding of the coding scheme (inter-coder agreement was above 95% for all pairs of coders). Each coder then coded a quarter of the conversations independently. The number of sentences belonging to each category was counted within each week. Then the average number of sentences for each of the four week-types was calculated.

RESULTS

The effect of *CMC channels, level of difficulty* and *level of conflict* on participants' performance and conversation dynamics was examined. Mediation analyses were then performed to further reveal the process of how participants' communication strategies during information exchange predicted their involvement in negotiation, which in turn foreshadowed their performance.

Performance

Overall Performance

The *overall performance* did not differ between the three CMC groups ($M = 13.58$, 13.80 and 13.91, $SD = .85$, $.41$ and $.49$ for text, audio and video conditions, respectively, $F_{(2,47)} = 1.30$, $p > .10$). To further understand whether more

balanced solutions were reached as a result of thorough negotiation, the *difference score* between each dyad was used as the dependent variable in the following analyses.

Level of Difficulty

Mixed-design analysis of variance (ANOVA) with *difficulty* as a repeated measure and CMC channels as between-subject variable yielded a significant interactive effect ($F_{(2,47)} = 4.78$, $p < .05$) on the difference scores of dyads, suggesting that different CMC groups performed differently on easy vs. difficult weeks. As illustrated in Figure 3a, the difference in participants' performances was comparable among three CMC groups for *easy* weeks ($F_{(2,47)} = 1.20$, $p > .10$). In contrast, difference in participants' performances on *difficult* weeks differed for the three CMC groups ($F_{(2,47)} = 3.60$, $p < .05$). Fisher's least significant difference (LSD) post-hoc comparison suggested that the difference in performance was higher for text and audio groups than video groups ($ps < .05$).

The results suggested that when the task became difficult, participants in video condition were able to reach a decision that better balanced the two sides' performance, as reflected in a smaller difference score, suggesting that they probably were able to get more involved in conflict resolution by negotiating with each other on difficult weeks.

Level of Conflict

Also taking participants' difference in performance as dependent variable, mixed-design ANOVA with *level of conflict* as a repeated measure and CMC channels as between-subject variable yielded a significant 2-way interactive effect ($F_{(2,47)} = 5.92$, $p < .01$), suggesting that different CMC groups also performed differently on weeks with low vs. high levels of potential conflict.

As shown in Figure 3b, for *low-conflict* weeks, CMC channels had a marginal effect on dyads' difference in performance ($F_{(2,47)} = 2.42$, $p = .10$). The effect of CMC channels was significant for *high conflict* weeks ($F_{(2,47)} = 4.40$, $p < .05$). Fisher's LSD post-hoc comparison suggested that the difference in performance was lowest for the video condition, which was lower than text condition ($p < .01$), and was marginally lower than audio condition ($p < .10$).
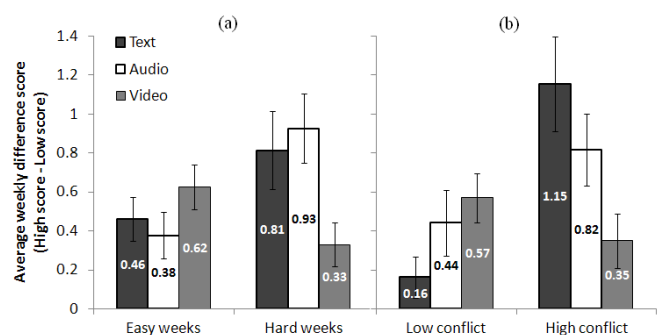

Figure 3. Difference score for easy vs. difficult weeks (a) and for low- vs. high-conflict weeks (b) in text, audio and video CMC groups

We can clearly see from Figure 3b that, as the bandwidth of CMC channels went higher from text to audio and from audio to video chatting, the difference score between dyads became smaller and smaller for high-conflict weeks, probably due to the fact that they were more and more likely to get engaged in negotiation and conflict resolutions when they need to. To further unpack the impact of CMC channels, we examined participants' conversation dynamics on how they exchanged availability information and the extent to which they got involved in negotiation.

Conversation Dynamics
Two aspects of participants' conversation were examined. First, at the stage of collaboratively identifying potential solutions, participants might use different *communication strategies* when exchanging information about their availability, which in turn might bring an effect on their subsequent negotiation and conflict resolution based on the identified solution candidates. Second, participants' involvement in *negotiation* was directly compared among different CMC groups for different week types.

Communication Strategies during Information Exchange
We examined the number of sentences participants used for suggesting times in *condensed* vs. *specific format*. Figure 4 clearly illustrated the different preferences participants have in choosing condensed vs. specific format to convey their own availability and to ask their partners' availability. Mixed-design ANOVA with information exchange format (condensed vs. specific) as repeated measures and CMC channels as between-subject variable yielded a significant 2-way interactive effect between the two variables ($F_{(2,47)}$ = 24.69, p < .001). Although participants said more sentences in specific format than in condensed format in all three CMC groups (paired-sample $t_{(16)}$ = 2.26, $p < .05$, $t_{(15)}$ = 9.74, $p < .001$, and $t_{(16)}$ = 12.02, $p < .001$ for text, audio and video conditions, respectively), the difference in video condition was the highest, followed by audio condition. This pattern of result was consistent across all week types.
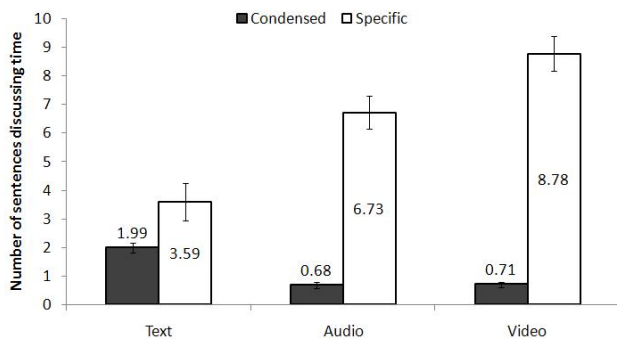

Figure 4. Number of sentences conveying availability in condensed vs. specific format.

The results clearly showed that participants in our study employed different strategies at the stage of information exchange to collaboratively find potential solutions. The choice of different strategies probably was due to the cost of different communication channels. Specifically, the high

cost of typing and the easiness of retrieving information by looking back at the text history probably made the text group prefer laying out all their available times at once, whereas the low cost of talking and the difficulty of holding information in working memory probably made the audio and video groups prefer discussing a small number of possible time slots before moving onto other ones.

Since it would be very difficult to discuss a large amount of information conveyed in condensed format and compare a large number of solution candidates all at once, a prerequisite of sufficient negotiation would be discussing potential solutions in specific rather than condensed format, which happened more often in audio and video conditions. Therefore, we would expect that the different preferences on information exchange strategies would foster different levels of negotiation in the three CMC groups.

Negotiation
To control for the influence of overall talkativeness on participants' involvement in negotiation, we divided the number of sentences participants actually said (typed) on score-evaluation and negotiation for each week by the weekly average number of sentences said by the CMC group this dyad was from. We then used this *proportional score* to represent participants' involvement in negotiation.

Mixed-design ANOVA did not find a significant interactive effect between *difficulty* and CMC channels on the extent to which participants involved in negotiation ($F_{(2,47)}$ = .35, $p > .10$, see Figure 5a). A main effect of week types ($F_{(1,47)}$ = 16.18, $p < .01$) suggested that difficult weeks elicited more negotiation than easy weeks. The main effect of CMC channels was not significant ($F_{(2,47)}$ = 1.65, $p > .10$).

In contrast, *conflict level* and CMC channels had a significant two-way interactive effect on involvement in negotiation ($F_{(2,47)}$ = 3.76, $p < .05$, see Figure 5b). Paired-sample t-tests comparing low- vs. high-conflict weeks suggested that the proportion of sentences devoted to negotiation was similar for text condition ($t_{(16)}$ = .03, $p > .10$), marginally different for audio condition ($t_{(15)}$ = 1.88, p = .08), and significantly different for video condition ($t_{(16)}$ = 5.21, p < .001). Thus, participants were more likely to get involved in negotiation for weeks involving higher levels of potential conflict in video condition, probably as an effort of resolving these conflicts.
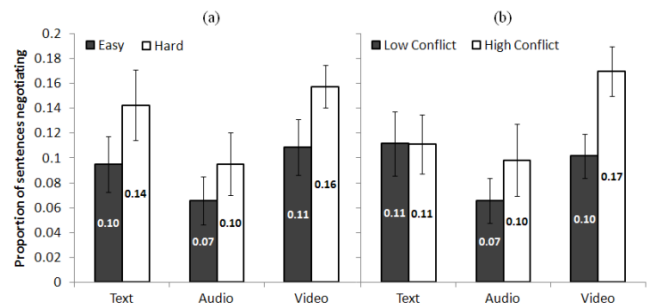

Figure 5. Involvement in negotiation for easy vs. difficult weeks (a) and low- vs. high conflict weeks (b).

The Mechanism of Why Video Chatting Better Supports Conflict Resolution
Recall that participants using video chatting were able to reach decisions that better balanced the performance of both sides when the tasks were difficult or involved higher levels of potential conflict. The goal of this section was to understand the underlying mechanisms of how participants' different conversation dynamics resulted in these performance patterns when using different CMC channels. Specifically, we hypothesized that communication strategies participants chose to exchange availability information established a common ground that influenced their involvement of subsequent negotiation, which in turn led to the different performance patterns. Mediation analysis was used to examine whether there was an effect flowing along this chain.

Mediation Analysis
Mediation analysis is commonly used in social science studies to identify the effects that transmit along a chain of variables [25]. The standard procedure of examining whether a mediation effect exists involves four steps of regression analyses [5] (see Figure 6).

Step1: Independent variable (X) has a significant effect (path c) on dependent variable (Y). Thus, there is an effect to be mediated.

Step2: X has a significant effect (path a) on mediator (M).

Step3: M has a significant effect (path b) on Y controlling for X (when X is taken into account). That is, both X and M should be entered in the regression equation to predict Y.

Step4: The effect of X on Y (path c') controlling for M is reduced compared to the original effect (path c). When c' is reduced to 0, it is a full mediation, otherwise a partial mediation. The indirect effect of X on Y through M (i.e., the reduction of effect from c to c') can be tested using the method promoted by Sobel [32].
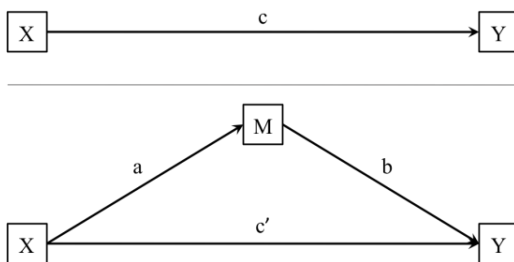

**Figure 6. Conceptual Framework of Mediation Analysis**

When a mediation effect is detected, one can conclude that M fully or partially mediated the effect from X to Y. That is, the antecedent variable X affects the mediating variable M, which in turn affects the outcome variable Y.

Negotiation Mediating the Effect of Communication Strategies during Information Exchange on Performance
Twelve sets of mediation analyses were conducted (4 week types X 3 CMC groups, one model each). In the analyses, the two communication strategies (condensed vs. specific) during information exchange were entered as independent variables (X), negotiation was entered as the mediator (M), and performance as measured in difference score for each dyad was entered as the outcome variable (Y). Mediation was detected only for high conflict weeks in the video group. Therefore, we will focus on this particular mediation model and the rest 11 models are not reported in detail in this article.

The whole mediation model is presented in Figure 7, with path coefficients (β) marked along each path. Exchanging information in condensed format did not have an effect on negotiation ($\beta = .09$), or on dyads' difference scores ($\beta = -.24$). However, exchanging information in specific format had a positive effect on negotiation (path a, $\beta = .61$, $p < .05$). That is, participants who exchanged availability information one or two small time slots at a time were more likely to get engaged in negotiation. Exchanging less information at a time had a negative effect on dyads' difference scores (path c, $\beta = -.69$, $p < .01$) before examining the mediation effect of negotiation. That is, exchanging availability information one or two small time slots at a time could also reduce the score difference between the two sides of each dyad, helping them reach a consensus that balanced the score each side could earn. Negotiation had a negative effect on the dyads' difference scores controlling for both condensed and specific format of information exchange (path b, $\beta = -.52$, $p < .05$). Thus, involvement in negotiation also helped getting the dyads reach better balanced decisions. Most importantly, when negotiation was taken into account in regression, the effect of exchanging less information at a time on performance was reduced to a non-significant effect (path c', $\beta = -.37$, $p = .10$). The reduction of effect was marginally significant ($\Delta = .32$, $p = .06$) according to Sobel Test [28, 32]. Therefore, negotiation mediated the effect of exchanging a smaller amount of information at a time on reducing difference scores between the two sides of participant dyads in video condition when conflict level was high.
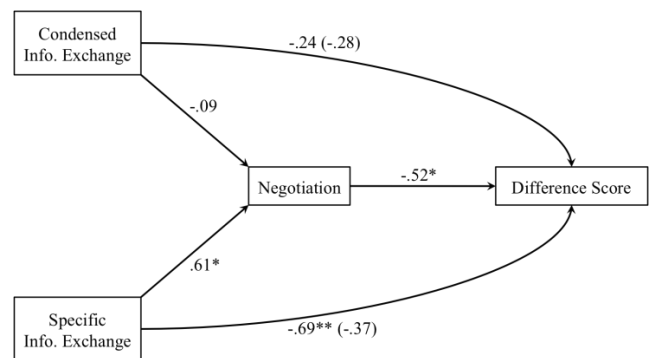
*: $p < .05$, **: $p < .01$

Figure 7.Negotiation mediating the effect of communication strategies on performance for high-conflict weeks in video condition. Note: numbers along the paths are standardized regression coefficients (β). The number in parentheses are regression coefficients when mediator (negotiation) was controlled for (i.e., path c').

The mediation analyses explained the mechanism of why participants in the video group were able to reach a well-balanced decision for this event-scheduling task when the level of potential conflict was high. Participants had a high tendency to exchange availability information in specific format (fewer than two 2 time slots at each conversation turn) when video chatting. This particular communication strategy established a common ground that better fostered negotiation, which was essential for conflict resolution. Thorough and in-depth negotiation then resulted in better-balanced performance for the dyads as reflected in smaller difference scores.

Table 3 illustrated example sections of conversation turns in text and video condition. We can see that in text condition, T2 mentioned 6 time slot candidates in one sentence. Although T1 compromised by taking one less preferred option, the pair reached a decision without in-depth discussion on all possible alternatives. Therefore, this decision might be sub-optimal. In comparison, the pair in video condition discussed one alternative at a time and was aware that both the available alternatives would require compromise from one side or the other before V2 compromised. V1 also offered to compromise in the future to ensure a feeling of fairness to V2.

Text	Video
T1: ok week 5, aug 30-sept 3 now?	V1: So 10 to 11 on Friday?
T2: yes, mon 2-3, tues 12-1, wed 11-12 4-5, fri 9-10 11-1, white	V2: 10 to 11, you can't do 11 to 12?
	V1: Umm it's blue
	V2: Can you do 12 to 1?
	V1: It's green, would that work?
	V2: Ok so it's green one way or the other, so let's do 10 to 11
T1: mon 2-3 works, and fri 11-12 is green for me, i will go with it, fine?	V1: Ok
	V2: 10 to 11 on Friday, and that way you get a white and I get a green
	V1: Ok that works, and we can compromise, I can do a green next, ok so now we're on week 3
T2: ok cool	

Table 3. Example conversation exchanges in text and video condition.

A further look at the models for text and audio groups could reveal whether similar mechanisms also exist for these two communication channels. When conflict level was high, none of the paths in the mediation model was significant for the text group. Whereas for the high-conflict weeks in the audio group, information exchange in specific format had a positive effect on negotiation (path a), but negotiation was not predictive of the dyads' performance (path b). This result indicated that negotiation in audio condition was less effective in resolving conflicts than in video chatting, probably due to the lack of visual cues such as attentional focus, facial expressions and gestures.

CONCLUSION AND DISCUSSION
In the current study, we examined the effect of text-, audio- and video-based CMC channels on how people resolved conflicts and reached agreement in an appointment-scheduling task. Two within-subject variables (difficulty, level of conflict) were introduced to further decompose the dynamics of interaction within participant pairs throughout the conflict resolution process. In particular, we focused on the difference in performance between each participant dyad because this difference was a good indicator of how well conflicts were resolved, and reflected the effectiveness of communication and negotiation in each CMC method.

In general, our results were supportive of the idea that higher bandwidth could help with conflict resolution. First, participants who used the video-based communication method were more likely to agree on solutions that were equally good to both parties, especially in difficult and high conflict weeks, than participants who used the text- and audio-based channels. Second, analyses on conversation dynamics showed that participants using different CMC channels employed different strategies when exchanging information to establish common ground for the following stage of negotiation and conflict resolution. Specifically, we found that time information was exchanged in a more condensed format in text condition and smaller chunks of more specific time information was discussed in audio and video conditions. Third, we found that the extent to which participant dyads were engaged in negotiation was most sensitive to the level of conflict of a week when the video-based communication method was used.

Lastly but most importantly, mediation analyses revealed the underlying mechanism of why conflict resolution was better supported by the video channel. Because of the low cost of speaking than typing and the difficulty of holding too much information in working memory, participants tended to exchange less information at a time. They then began to discuss the information exchanged before moving onto exchanging the next piece of information. We found that this communication strategy fostered a thorough negotiation that was essential for conflict resolution, which in turn led to a better balance of performance between the collaborators.

This mediational mechanism explained why participants were less able to reach balanced performance when communicating through text and audio channels. High cost of typing and the easiness of looking for information from text history rather than retrieving from working memory probably made the participants prefer the choice of laying out all information at once when using the text channel. Although this strategy could be efficient in exchanging information as fast as possible, it would be hard to negotiate and compare among an overwhelmingly large number of solution candidates. When communicating through audio channel, participants also preferred the way of exchanging less information each time, similar to participants in the video group. This information exchange strategy supported

a higher level of negotiation. But negotiation in the audio group seemed to be less efficient than the video group, as negotiation did not predict performance in the mediation model for the audio group. This was probably due to the fact that participants were less efficient in inferring their partner's goals, emotion, willingness to compromise, personality and other social cues that are essential for successful negotiation and conflict resolution. However, it is important to point out that the exact reasons of why participants chose different information exchange strategies when using different communication channels were not directly examined but speculated in the current study. Future studies need to identify possible antecedents of people's choice on information exchange strategies.

Further field studies are needed to verify the ecological validity and the generalizability of the findings from this study. However, it is highly probable that the same mechanism also arise in real-world negotiation scenarios as well as tasks that involve conflict resolution in a more complicated format. The strategy of exchanging information in small pieces at each time can be particularly helpful to establish common ground that better supports negotiation, especially when there is a large amount of information in the task space and a great proportion of it needs to be exchanged via communication among group members. Focusing on small chunks of information can help the collaborators stay synchronized in acknowledging and updating their status during the process of collaborative work. This strategy can also help reduce the chance of collaborators neglecting certain pieces of information that is particularly important due to the overwhelmingly large amount of information exchanged all at once.

Implications

The results of the current study provided insights on how the dynamics of interpersonal interaction induced by different CMC channels could influence the negotiation and conflict resolution processes. We believe that one important metric for successful conflict resolution is whether both parties can agree on a solution that is equally good for them. A high difference in performance or earned benefits in remote conflict resolution tasks can bring long-term detrimental effects on how collaborators judge the overall value of the collaboration, as well as their mutual trust [7]. In the long run, the trust and willingness to collaboration might diminish if either party perceives that there is an imbalance of benefits or costs in the collaboration, which apparently would result in an escalation of conflict level [29] and less efficient long-term effectiveness in the collaborative work. Therefore, special attention need to the paid to whether the interfaces of CMC tools could facilitate a feeling of "fairness" and trust among remote collaborators when they need to resolve conflicts through remote communication.

The results of the current study also brought important implications to the design of CMC tools to better support conflict resolution. Although increasing the bandwidth of the communication channel from text to audio, and from audio to video could be a solution to provide better support, sometimes this upgrading can be costly. According to our results, low bandwidth CMC tools can be designed to promote information exchange in small pieces at each conversation turn, so that users can be guided to thoroughly discuss information in small bits at a time before moving on to the next bit and to avoid getting lost and not knowing how to negotiate by laying out a large chunk of information all at once. In addition, new features can also be incorporated into low bandwidth CMC tools to help organize the exchanged information and related discussion. By grouping each piece of information together with corresponding discussion and negotiation, the tool could provide a structural help to the users on keeping track of the progress of conflict resolution. This could be especially helpful for tasks that are complex.

Future Directions

The process of conflict resolution could become even more complicated when other factors are taken into consideration in the dynamic process, such as collaborators' personality traits and sensitivity to others' emotions, intentions and needs, features in the communication tools such as time lag and quality of audio and video streams, translation of language and different group norms when multiple groups scattering all over the world are involved in the collaborative work. This may imply that there is no single best CMC method for all remote collaborative works. Perhaps it is more reasonable to choose different channels depending on the nature of the remote task, the individuals performing the task, and the individual and collective goal orientation of the team (e.g., competitive vs. collaborative goals). Future research should be focused on the complex interactions of these factors during remote collaborative work involving conflict resolution.

REFERENCES

1. Anderson, A.H., McEwan, R., Bal, J., et al. Virtual team meetings: An analysis of communication and context. *Computers in Human Behavior*, 2007. 23: p. 2558-2580.

2. Baddeley, A. Working Memory. *Science*, 1992. 255(5044): p. 556-559.

3. Balakrishnan, A.D., Fussell, S.R., and Kiesler, S. Do visualizations improve synchronous remote collaboration?, in *Proceeding of the 26th annual SIGCHI conference on Human factors in computing systems*. 2008, ACM: Florence, Italy.

4. Baltes, B.B., Dickson, M.W., Sherman, M.P., et al. Computer-Mediated Communication and Group Decision Making: A Meta-Analysis. *Organizational Behavior and Human Decision Processes*, 2002. 87(1): p. 156-179.

5. Baron, R.M. and Kenny, D.A. The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations. *Journal of Personality & Social Psychology*, 1986. 51(6): p. 1173-1182.

6. Bordia, P. Face-to-Face Versus Computer-Mediated Communication: A Synthesis of the Experimental Literature. *Journal of Business Communication* 1997. 34(1): p. 99-118.

7. Bos, N., Olson, J., Gergle, D., et al. Effects of Four Computer-Mediated Communications Channels on Trust Development. in *ACM Conference on Human Factors in Computing Systems*. 2002. Minneapolis, MN. 4(1): p. 135-140.

8. Brett, J.M. *Negotiating Globally*. 2001, San Francisco, CA: Jossey-Bass.

9. Chapanis, A., Ochsman, R.B., Parrish, R.N., et al. Studies in Interactive Communication: I. The Effects of Four Communication Modes on the Behavior of Teams During Cooperative Problem-Solving. *Human Factors*, 1977. 14(6): p. 487-509.

10. Clark, H.H. and Brennan, S.A. Grounding in communication, in *Perspectives on socially shared cognition* L.B. Resnick, J.M. Levine, and S.D. Teasley, Editors. 1991, APA Books: Washington.

11. Cramton, C.D. The Mutual Knowledge Problem and Its Consequences for Dispersed Collaboration. *Organization Science*, 2001. 12(3): p. 346-371.

12. Daft, R.L. and Lengel, R.H. Information Richness. A New Approach to Managerial Behavior and Organization Design, in *Research in Organizational Behavior*, L.L. Cummings and B.M. Staw, Editors. 1984, JAI Press.: Homewood, IL. p. 191-233.

13. Daly-Jones, O., Monk, A., and Watts, L. Some advantages of video conferencing over high-quality audio conferencing: fluency and awareness of attentional focus. *International Journal of Human-Computer Studies*, 1998. 49(1): p. 21-58.

14. Diamant, E.I., Fussell, S.R., and Lo, F.-l. Where did we turn wrong?: unpacking the effect of culture and technology on attributions of team performance, in *Proceedings of the 2008 ACM Conference on Computer Supported Cooperative Work*. 2008, ACM: San Diego, CA, USA.

15. Dong, W. and Fu, W.T. Conflict Resolution in Remote Collaborative Problem Solving: A Comparison of Different Computer Mediated Communication Methods. in *The Annual Meeting of the Cognitive Science Society*. 2011. Boston, MA. p. 2142-2147.

16. Dorado, M.A., Medina, F.J., Munduate, L., et al. Computer-mediated negotiation of an escalated conflict. *Small Group Research*, 2002. 33(5): p. 509-524.

17. Firm, K., Sellen, A., and Wilbur, S. *Video-mediated communication*. 1997, Hillsdale, NJ: Lawrence Erlbaum Associates.

18. Fish, R.S., Kraut, R.E., Root, R.W., et al. Video as a technology for informal communication. *Commun. ACM*, 1993. 36(1): p. 48-61.

19. Fussell, S.R. and Krauss, R.M. Coordination of Knowledge in Communication: Effects of Speakers' Assumptions About What Others Know. *Journal of Personality & Social Psychology*, 1992. 62(3): p. 378-391.

20. Fussell, S.R., Kraut, R.E., Gergle, D., et al. Visual Cues as Evidence of Others' Minds in Collaborative Physical Tasks, in *Other Minds*, B. Malle and S. Hodges, Editors. 2005, The Guilford Press: New York. p. 91-105.

21. Goh, K.-Y., Teo, H.-H., Wu, H., et al. Computer-supported negotiations: an experimental study of bargaining in electronic commerce. in *7th International Conference on Electronic Commerce*. 2000. p. 104-116.

22. Hinds, P.J. and Bailey, D.E. Out of Sight, Out of Sync: Understanding Conflict in Distributed Teams. *Organization Science*, 2003. 14(6): p. 615-632.

23. Hollingshead, A.B. Information Suppression and Status Persistence in Group Decision Making The Effects of Communication Media. *Human Communication Research*, 1996. 23(2): p. 193-219.

24. Kiesler, S. and Sproull, L. Group decision making and communication technology. *Organizational Behavior and Human Decision Processes*, 1992. 52: p. 96-123.

25. MacKinnon, D.P., Fairchild, A.J., and Fritz, M.S. Mediation Analysis. *Annual Review of Psychology*, 2007. 58: p. 593-614.

26. Morris, M., Nadler, J., Kurtzberg, T., et al. Schmooze or lose: Social friction and lubrication in e-mail negotiations. *Group Dynamics: Theory, Research and Practice*, 2002. 6(1): p. 89-100.

27. Olson, J.S., Olson, G.M., and Meader, D.K. What mix of video and audio is useful for small groups doing remote real-time design work?, in *Proceedings of the CHI'95 conference on Human Factors in Computing Systems*. 1995, ACM Press: Denver, CO. p. 362-368.

28. Preacher, K.J. and Hayes, A.F. SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behavior Research Methods, Instruments, & Computers*, 2004. 36(4): p. 717-731.

29. Schoorman, F.D. and Holahan, P.J. Psychological antecedents of escalation behavior: Effects of choice, responsibility and decision consequences. *Journal of Applied Psychology*, 1996. 81: p. 786-794.

30. Setlock, L.D., Quinones, P.-A., and Fussell, S.R. Does Culture Interact with Media Richness? The Effects of Audio vs. Video Conferencing on Chinese and American Dyads. in *Hawaii International Conference on System Sciences*. 2007.

31. Siegel, J., Dubrovsky, V., Kiesler, S., et al. Group processes in computer-mediated communication. *Organizational Behavior and Human Decision Processes*, 1986. 37(2): p. 157-187.

32. Sobel, M.E. Asymptotic Confidence Intervals for Indirect Effects in Structural Equation Models. *Sociological Methodology*, 1982. 13: p. 290-312.

33. Tan, D.S., Gergle, D., Mandryk, R., et al. Using job-shop scheduling tasks for evaluating collocated collaboration. *Journal of Personal and Ubiquitous Computing*, 2008. 12: p. 255-267.

34. Thompson, L. and Nadler, J. Negotiating via information technology: Theory and application. *Journal of Social Issues*, 2002. 58(1): p. 109-124.

35. Veinott, E.S., Olson, J., Olson, G.M., et al. Video helps remote work: speakers who need to negotiate common ground benefit from seeing each other, in *Proceedings of the SIGCHI conference on human factors in computing systems: the CHI is the limit*. 1999, ACM: Pittsburgh, Pennsylvania, United States. p. 302-309.

36. Wee, H.-S.s., pirkul, H., Jacob, V., et al. Effects of Computer-Mediated Communication on Group Negotiation: An Empirical Study. in *28th Annual Hawaii Intenational Conference on System Sciences* 1995. p. 270-279.