Social and behavioural correlates to effective problem solving in meta-teams

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Abstract

The tendency for organizations, including the Canadian Armed Forces, to solve problems using meta-teams, or teams of individuals from various organizations, has created a need to understand the nature of collaborative performance within potentially competitive climates. While the use of meta-teams allows members to draw upon diverse experience and expertise not available within one organization, creating a potentially more efficient mechanism for dealing with tasks or solving problems, individual members may place the needs of their home organization above what is best for the meta-team, creating a potentially competitive environment. Distributed teams, in particular, may face challenges in developing the relationships amongst meta-team members that are necessary for effective meta-team collaboration. Thirty meta-teams of 4 participants, each of whom was assigned to one of four higher-order groups (akin to home organizations), worked on a series of problem-solving tasks that required at least some level of elicited cooperation in order to be successful. Half of the teams worked face-to-face and half of the teams used computer-mediated communication only. Points were awarded to individual participants based on whether and how the problem was solved (i.e., as a team or alone). Participants' coded interactions as well as their post-interaction ratings of their meta-teammates were assessed using non-parametric tests and multilevel modeling. The results indicated that distributed and face-to-face meta-teams were equally effective when it came to solving the problems, but that the nature of the problem solving was dependent on the nature of the team. Face-to-face teams were much more collaborative in their work and were also much more likely to have positive views of each other. However, face-to-face team members who over-shared their information and asked many (often repetitive or redundant) questions created confusion amongst their teammates, and a fixation on certain information, thus making it less likely that they would be successful in their attempts at problem solving. Although subject to further validation, these results point to behaviours that may be useful when attempting to establish an effective meta-team working environment.

Significance to defence and security

The tendency of recent military operations to have an interagency, multinational, or multi-team focus has necessitated the understanding of how "meta-team" collaboration might be encouraged within a competitive environment. The current study examined the social, environmental, and behavioural factors that may influence successful collaboration within meta-teams. The findings suggest that for collaborative problem solving to be encouraged within meta-teams, face-to-face interactions that are not dominated by offers and requests for information are most effective. While distributed teams are as likely to solve problems as face-to-face teams, their problem solving tendencies lack the collaborative nature that face-to-face teams exhibit. In addition, the findings suggest that greater within-team liking, which was more characteristic of face-to-face teams, is associated with superior problem-solving. One key element that was evidenced in the current research indicated that, in order for effective problem solving to occur, the information sharing exhibited by team members, whether in the form of requests or offers of information, must be tempered to ensure that information is logically assessed. As evidenced in the current research, groups may fixate on repeated information, creating an environment of groupthink (Janis, 1972) that hinders problem solving behaviours.

Résumé

La tendance pour les organisations, y compris les Forces armées canadiennes, à résoudre des problèmes à l'aide de méta-équipes ou d'équipes de personnes provenant de diverses organisations a suscité le besoin de comprendre la nature du rendement collaboratif dans des milieux où il peut y avoir de la concurrence. L'utilisation de méta-équipes permet aux membres de s'appuyer sur une expérience et une expertise diversifiée qui ne sont pas toujours présentes au sein d'une même organisation. Cela permet de créer un mécanisme de traitement des tâches et de résolution de problèmes qui peut se révéler plus efficace. Cependant, il se peut que des personnes favorisent les intérêts de leur propre organisation d'attache plutôt que de rechercher ce qu'il y a de mieux pour la méta-équipe, créant ainsi un milieu où il peut y avoir de la concurrence. Les équipes réparties, en particulier, peuvent se heurter à des difficultés lorsqu'il s'agit d'établir des relations entre les membres de la méta-équipe, relations nécessaires à une collaboration efficace. Trente méta-équipes de quatre participants, chacune d'elles affectée à l'un des quatre groupes d'ordre supérieur (s'apparentant aux organisations d'attache), ont travaillé à un ensemble de tâches de résolution de problèmes qui nécessitaient au moins un certain niveau de collaboration pour assurer leur réussite. La moitié des équipes ont travaillé face à face, alors que l'autre moitié n'a utilisé que les communications électroniques. On a accordé des points à chacun des participants en fonction des aspects suivants : la résolution du problème et la façon dont il a été résolu (c.-à-d., en équipe ou par une seule personne). On a évalué les interactions codées des participants et déterminé le classement après les interactions de leurs coéquipiers de la méta-équipe à l'aide de tests non paramétriques et de modèles à niveaux multiples. Les résultats montrent que les équipes réparties, tout comme les méta-équipes travaillant face à face, ont été efficaces lorsqu'il s'agissait de résoudre des problèmes, mais que la nature de la résolution dépendait de celle de l'équipe. Les équipes face à face travaillaient davantage en collaboration et étaient plus susceptibles d'avoir une perception positive les unes des autres. Cependant, les membres des équipes face à face qui échangeaient trop d'information et qui posaient de nombreuses questions (souvent répétitives ou redondantes) suscitaient la confusion chez leurs coéquipiers et les amenaient à fixer leur attention sur certaines informations. Ils étaient ainsi moins susceptibles de parvenir à résoudre les problèmes. Même s'ils doivent faire l'objet d'une nouvelle validation, ces résultats indiquent les comportements qui pourraient être utiles lorsqu'on tente d'instaurer le milieu de travail d'une méta-équipe efficace.

Importance pour la défense et la sécurité

En raison de la tendance récente en matière d'opérations militaires qui consiste à s'appuyer sur une équipe interorganisationnelle, multinationale ou sur plusieurs équipes, il est devenu nécessaire de comprendre comment on peut favoriser la collaboration d'une méta-équipe au sein d'un milieu concurrentiel. La présente étude aborde les facteurs sociaux, environnementaux et comportementaux pouvant contribuer au succès d'une collaboration au sein des méta-équipes. Les résultats montrent que pour encourager la résolution de problèmes en collaboration au sein des méta-équipes, les interactions face à face qui ne sont pas sous l'emprise d'offres et de demandes d'information sont les plus efficaces. Même si les équipes réparties sont tout aussi susceptibles de résoudre les problèmes que les équipes face à face, il leur manque l'esprit de collaboration dont font preuve ces dernières. De plus, les résultats semblent indiquer que plus l'appréciation est grande au sein de l'équipe, une caractéristique des équipes face à face, plus l'aptitude à résoudre des problèmes est élevée. L'un des éléments clés qui sont ressortis de la recherche actuelle indique que pour résoudre les problèmes de manière efficace, l'échange d'information entre les membres de l'équipe, que ce soit sous la forme de demandes ou d'offres d'information, doit être modéré afin que celle-ci puisse être évaluée en toute logique. Comme le démontre la présente recherche, les groupes peuvent concentrer leur attention sur une information répétée, créant ainsi une pensée de groupe (Janis, 1972) qui fait obstacle aux comportements favorisant la résolution de problèmes.

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1 Introduction

The changing requirements to conduct projects and/or operations using multidisciplinary expertise within the private and public sectors has meant that the use of teams from diverse environments ranging from industry to government to the military has become increasingly necessary. It is often essential for success to be able to draw upon knowledge and expertise that does not exist in one's own organization. Teamwork allows for the contribution of divergent inputs of knowledge and expertise from various team members in order to solve complex problems (Shanahan, Best, Finch, & Sutton, 2007). Due to the growing trend of organizational interdependence, then, working in teams may also mean working across agencies. These types of teams are known as "meta-organizations" or "meta-teams." Collaboration across agencies or groups, or within meta-organizations, is oftentimes difficult, in part, due to differing agency cultures and motivations. Working in an interagency team, or meta-organization, then, may create tension within individual group members between working collaboratively with other meta-organizational team members and acting in the best interest of the agency or organization to which they belong (i.e., the "home organization"). While the best interests of the meta-organizational team and the home organization are generally not mutually exclusive, it is important to understand the consequences of instances in which these interests are at least partially at odds with one another. One such example might be a cross-jurisdictional search for a fugitive. While it is in the best interest of the multiple departments to work together to capture the fugitive, each department may be motivated to "get the collar" for their own department, thus bestowing that department with prestige.

One obstacle to effective collaboration within a meta-team situation is the fact that these teams are often established as a temporary solution to deal with a specific problem, frequently for a short period of time. In order to effectively handle a task that requires that team members are dependent on one another to achieve a goal, meta-team members must establish "swift trust" (Meyerson, Weick, & Kramer, 1996). While groups stemming from more traditional, long-term organizational structures have the luxury of time to establish trust amongst team members, temporary groups require that team members quickly trust that other team members will not act to willfully harm them in some way. Within a military context, this willful harm could take the form of "not having your team's back" in a firefight or not sharing vital information that could result in others being put in danger. According to Meyerson et al., this swift trust is generally based on the specific roles that team members play and the history that one has had with members who generally play that role. For example, because we trust doctors in other similar situations, we might be more likely to trust the doctor member of our team if he/she is acting in the capacity of his/her doctor role as opposed to acting in the capacity of another role (e.g., as an accountant). In comparison, in situations where roles are not clearly defined, the trust placed in an individual is felt to be riskier and the likelihood of trust violations is greater. However, in an interdependent system, trust may be based on the fact that team members need each other.

Another avenue to building trust within meta-teams is acting trustful. According to Meyerson et al. (1996), acts of trust create "social proof" that being trusting is appropriate in this situation. Thus, the more that one acts in a trusting manner, the more likely it is that others will also act in a trusting manner because that is the proper response in that situation and trusting, therefore, appears less risky. Trusting, according to Meyerson and her colleagues, becomes a self-fulfilling prophecy.

Factors, both social and personal, that influence rapid trust building and/or repair in teams, whether co-located or distributed, are vital for understanding interagency or meta-team collaboration. One factor that may have an impact on swift trust amongst team members within a meta-team context is the mode of communication available to them. There is an increasing trend for groups to employ computer-mediated communication (CMC), especially when individual team members come from diverse organizations that are widely distributed geographically. For this reason, it is important to consider the dynamics involved in CMC versus face-to-face communication. While trust tends to develop more slowly in CMC compared to face-to-face interactions, Wilson, Straus, and McEvily (2006) indicate that the impact of mode of communication on trust may disappear over time.

The nature of the interactions within CMC and face-to-face groups have also been found to differ. While CMC tends to be more task-oriented, face-to-face communication tends to be more cohesive and personal (Jonassen & Kwon, 2001). This cohesive and personal communication creates an environment where connections within groups are made and collaboration is fostered. Additionally, research has found that, at least in the short-term, group members working face-to-face like their group members more than those working using CMC (Okdie, Guadagno, Bernieri, Geers, & Mclarney-Vesotski, 2011; Sprecher, 2014; Walther, 1995; Weisband & Atwater, 1999). One reason that researchers believe that face-to-face communication fosters more positive impressions than CMC is the availability of nonverbal, expressive cues that do not exist in CMC (Walther, Anderson, & Park, 1994).[1] The absence of these social cues and the resulting depletion of emotional context for the computer-mediated messages leads to an extended "getting to know you" phase due to difficulties in message comprehension (e.g., misunderstanding message tone) and impression formation (Tanis & Postmes, 2003). Over time, however, the positive perceptions of CMC groups have been found to approach those of face-to-face groups (Chidambaram, 1996; Wilson et al., 2006).

While there are many consequences to not being liked by one's group members, a particularly important result within the context of problem solving is the potential that non-liked members of a group may be left "out-of-the-loop" during group discussions. While research has investigated the results of being left "out-of-the-loop" when it comes to group interactions and information sharing (e.g., Jones, Carter-Sowell, & Kelly, 2011; Jones & Kelly, 2010; Williams, Cheung, & Choi, 2000), no research could be found on the precursors to information exclusion (i.e., why are some people left "out-of-the-loop"?). However, Jones and Kelly (2010) did find that people who were left "out-of-the-loop" felt ostracized by their group and liked their group members less than "in-the-loop" participants, especially when the exclusion was deemed to be intentional. If people believe that they are receiving less information because they are liked less (i.e., being ostracized) then perhaps there is some foundation to this belief.

While the disadvantages of working in distributed teams via CMC have been noted, we should also note the potential advantages of working in distributed teams. According to Straus (1996), CMC allows for participation equalization. One potential reason for this equalization is the fact

[1] The research that has investigated this finding have compared face-to-face communication with text-based forms of CMC such as instant messaging or texting. However, it should be noted that there are other forms of CMC, such as videoconferencing, that would allow for the incorporation of nonverbal cues to some extent. Since the current study compares face-to-face groups with CMC groups that only have text-based communication available to them, the findings noted here are relevant for the hypotheses being drawn.

that individuals in the group do not have to compete to be heard, since messages can be typed simultaneously. Rains (2005) explains that participation equalization minimizes the dominance of the group by one person or a subgroup, allowing each voice to be heard equally. Another advantage to working in distributed teams via CMC is that CMC allows team members time to weigh and integrate the information provided by various voices (Mesmer-Magnus, DeChurch, Jimenez-Rodriguez, Wildman, & Shuffle, 2011). Due to the asynchronous nature of CMC, team members "have a greater opportunity to think through information shared by other members, think about responses before making them, and do research on questions posed by other members" and this "enables individuals to process information deeper than they would 'on the fly' in face-to-face meetings" (Mesmer-Magnus et al., 2011, p. 216). Finally, due to the increased time and effort it takes to use CMC (i.e., typing) as opposed to face-to-face interactions (i.e., speaking), individuals using CMC are less likely to provide extraneous or redundant information (Baltes, Dickson, Sherman, Bauer, & LaGanke, 2002). Therefore, the information exchanges among CMC groups are more likely than face-to-face groups to involve concrete, unique information.

Based on the previous research findings discussed above, a series of hypotheses regarding the problem-solving and collaborative behaviour of meta-teams was put forth. The following section outlines these hypotheses.

1.1 Hypotheses

The purpose of the present investigation was to examine the behavioural precursors to effective problem solving in meta-teams where both competitive and cooperative motivations exist. Motivations to compete or cooperate may exist in the Canadian Armed Forces (CAF), for example, when it must co-ordinate its activities or collaborate with other security partners or organizations (e.g., the Royal Canadian Mounted Police/RCMP, Health Canada) in a meta-organizational context (e.g., in responding to a natural disaster or emergency or a security threat).[2] The present study also sought to investigate how these behavioural precursors might differ when a team is distributed rather than physically or geographically co-located. To these purposes, this study formed participants into meta-teams and provided them with a problem-solving activity. During this activity participants were presented with only partial information and were required to collaborate to some degree with their meta-teammates by offering/requesting information and/or speculations in order to identify the details of a terrorist threat. The problem-solving task was followed by a Post-Interaction Questionnaire where participants were asked to assess their meta-teammates.

There were several hypotheses that were put forth and tested in this study. They are listed below:

1. No evidence to date has indicated that either CMC or face-to-face communication is a more effective means of communication for solving problems. In fact, as pointed out above, both modes of communication have advantages and disadvantages. Therefore, it was hypothesized that there would be no significant difference between distributed and co-located participants in the number of problems solved; however, it was hypothesized that the method of solving the problem might differ between the two modes of communication. Specifically, we

[2] Some possible examples of when such an emergency or threat may occur include, for instance, during the Vancouver 2010 Olympics, during a health-related epidemic, or during an ice storm or flood.

expected that because interactions within groups have been found to be more cohesive and personal, face-to-face meta-team members might be more collaborative and therefore more likely to share in the problem solving than would distributed meta-team members. In other words, we predicted that members of face-to-face meta-teams would be more likely to solve problems as a group, whereas members of distributed meta-teams would be more likely to solve problems as individuals.

2. It was hypothesized that there would be significant differences between communication conditions on a Post-Interaction Questionnaire (PIQ) as well. Because the research has indicated that initial impressions of group members are more positive within face-to-face compared to CMC groups, and due to the limited time-frame for the interactions within this study, it was believed that participants in the CMC groups would not have the time to form the positive impressions that develop more readily in face-to-face groups. Therefore, it was hypothesized that participants in the face-to-face condition (FtFc) would be viewed more positively by members of their meta-team and would have more positive views of the other members of their meta-team than would participants in the CMC or distributed condition (Dc).

3. Mesmer-Magnus et al. (2011) have indicated that the asynchronous nature of CMC allows individuals a greater opportunity to weigh and integrate information as compared to the "on the fly" thinking required in face-to-face interaction. Further, Rains (2005), has shown that there is greater equality evidenced in CMC as compared to face-to-face communication where one or more individuals may dominate the interactions. Group pressure imposed by these dominant group members may further hinder the deep understanding of the concrete information required to effectively problem-solve. Therefore, it was hypothesized that participants in the Dc, compared to participants in the FtFc, would be more likely to focus on concrete information. This deeper understanding of and focus on concrete information means that Dc participants were expected to analyze the information themselves and attempt to verify their analysis by submitting responses rather than by asking other meta-team members for opinions or verification. On the other hand, participants in the FtFc would be more apt to think "on the fly" and attempt to integrate information and form and discuss theories overtly. Therefore, the distribution of types of interactions was hypothesized to differ between conditions as follows:

    a. Participants in the distributed meta-team condition were hypothesized to spend more of their time requesting information, offering information, and submitting answers, as compared to participants in the face-to-face meta-team condition.

    b. Participants in the face-to-face meta-team condition were hypothesized to spend more of their time discussing strategies, offering speculations, requesting speculations, and clarifying (both asking and responding), as compared to participants in the distributed meta-team condition.

4. For the same reason that the types of interactions were expected to differ between communication conditions (see Hypotheses 3a and 3b), so too did we hypothesize that the types of interactions that would lead to successful problem solving would differ by communication condition in certain cases, as follows:

a. For both types of meta-team conditions (FtFc, Dc), we predicted that offering uninformative information or untrue/partial information would decrease the probability of a successful interaction, whereas we expected that cooperating/strategizing (e.g., deciding to parcel out the information according to type) would lead to an increase in the probability of a successful interaction.

b. For participants in the distributed meta-teams, we predicted that greater proportions of offering and requesting information would lead to an increase in the probability of a successful interaction.

c. In contrast, for participants in the co-located (face-to-face) meta-teams, we predicted that offers and requests of speculation would lead to an increase in the probability of a successful interaction.

5. Based on the research indicating that being left "out-of-the-loop" (i.e., not receiving information from group members) has been associated with feelings of being disliked, it was hypothesized that the level of liking would be associated with problem solving. Specifically, it was hypothesized that level of liking between the meta-team members, both how much a participant liked their meta-teammates and how well they were liked themselves, as measured by the overall PIQ, would predict the number of problems that a participant solved (i.e., the higher the level of liking, the greater the number of problems solved). This is because a well-liked individual would be more likely to obtain information from their meta-teammates (i.e., be "in-the-loop"). Conversely, meta-team members would be likely to withhold information (i.e., be "out-of-the-loop") from those individuals in the team that they disliked.

1.2 Summary

Due to a growing trend towards organizational interdependence, meta-teams, or teams made up of individuals drawn from different departments or organizations, have become increasingly popular. Such meta-teams allow for the contribution of a diverse wealth of knowledge and expertise from various team members in order to solve complex problems. Collaboration within meta-teams is oftentimes difficult and it is important to understand the dynamics involved in effective collaboration in these types of environments. Difficulties may stem from differing agency cultures and motivations, a lack of trust and liking amongst team members, distribution of the team, and consequently, the mode of communication available to them. It is important to understand the consequences of instances in which the interests of the meta-team are at odds with the interests of the larger organization from which a team member originates. Thus, this study examines some of the social and behavioural factors associated with effective problem solving in both distributed and face-to-face meta-teams.

2 Method

The methodology and questionnaires were reviewed and approved by the DRDC Human Research Ethics Committee (HREC) and all participants received remuneration according to DRDC guidelines.

2.1 Participants

Participants were 120 members of the York University community (117 students, 3 staff members) ranging in age from 17 to 55 ($M = 22.39$, $SD = 5.82$) who participated in the 90-minute study in exchange for $30.20 in remuneration and for the chance at a portion of a performance-based bonus.[3] The participants consisted of 46 males and 74 females.

All participants were run in sets of four in a laboratory setting and were randomly assigned to condition (face-to-face vs. distributed). They were assigned to a higher-order group (their "home organization") based on the laptop that they were using; however, the basis of this assignment was unknown to participants. All laptops were identical and no indicators for higher-order groups were visible prior to participants' beginning the experimental session. Placement of the laptops was rearranged from session to session so that no laptop was consistently in the same place relative to the room and relative to other laptops.[4]

The demographic composition of the participants in the FtFc was not significantly different from that of the Dc. Both the FtFc and the Dc consisted of 23 male and 37 female participants. Participants in the FtFc ranged in age from 17 to 55 ($M = 22.48$, $SD = 5.47$) and participants in the Dc ranged in age from 17 to 49 ($M = 22.31$, $SD = 6.19$). Within the FtFc there was one all-male team, one all-female team, two teams that were split 50/50 in terms of gender, nine teams that consisted of three females and one male, and one team that consisted of one female and three males. Within the Dc there were no all-male teams, one all-female team, three teams that were split 50/50 in terms of gender, eight teams that consisted of three females and one male, and three teams that consisted of three males and one female. This distribution of the composition of the teams did not differ significantly across conditions.

2.2 Procedures

Participants were recruited via posters, an online listing on the Undergraduate Research Participants Pool database at York University, and emails to the York University Psychology Graduate Students' List Serve. As participants indicated interest in participating, they were emailed a pre-experimental information package (see Annex A). Participants were scheduled in groups of four. Each session consisted of one meta-team. One-half (or 15) of the 30 meta-teams were assigned to the Ftfc, and 15 of the meta-teams were assigned to the Dc. The sessions were

[3] Participants who were part of the group that accumulated the most points were awarded a bonus, which consisted of a proportional share of a $500 prize.

[4] While the orientation of the laptops within the room or relative to the other laptops was not expected to impact the results, this rearrangement of laptops was done to mitigate any unforeseen impacts of laptop orientation.

counterbalanced with respect to condition using a random number generator. As participants arrived for their scheduled session, they were greeted by one of four available researchers (two male, two female)[5] and they were presented with the Voluntary Consent Form (see Annex B). Participants were asked to read and sign the consent form prior to moving forward with the experiment.

In the FtFc, participants were seated at one of four laptops positioned around a table in the centre of the lab. In the Dc, participants were seated at one of four laptops positioned in the four corners of the lab and were concealed from each other using moveable partitions or privacy screens (see Figure 1).

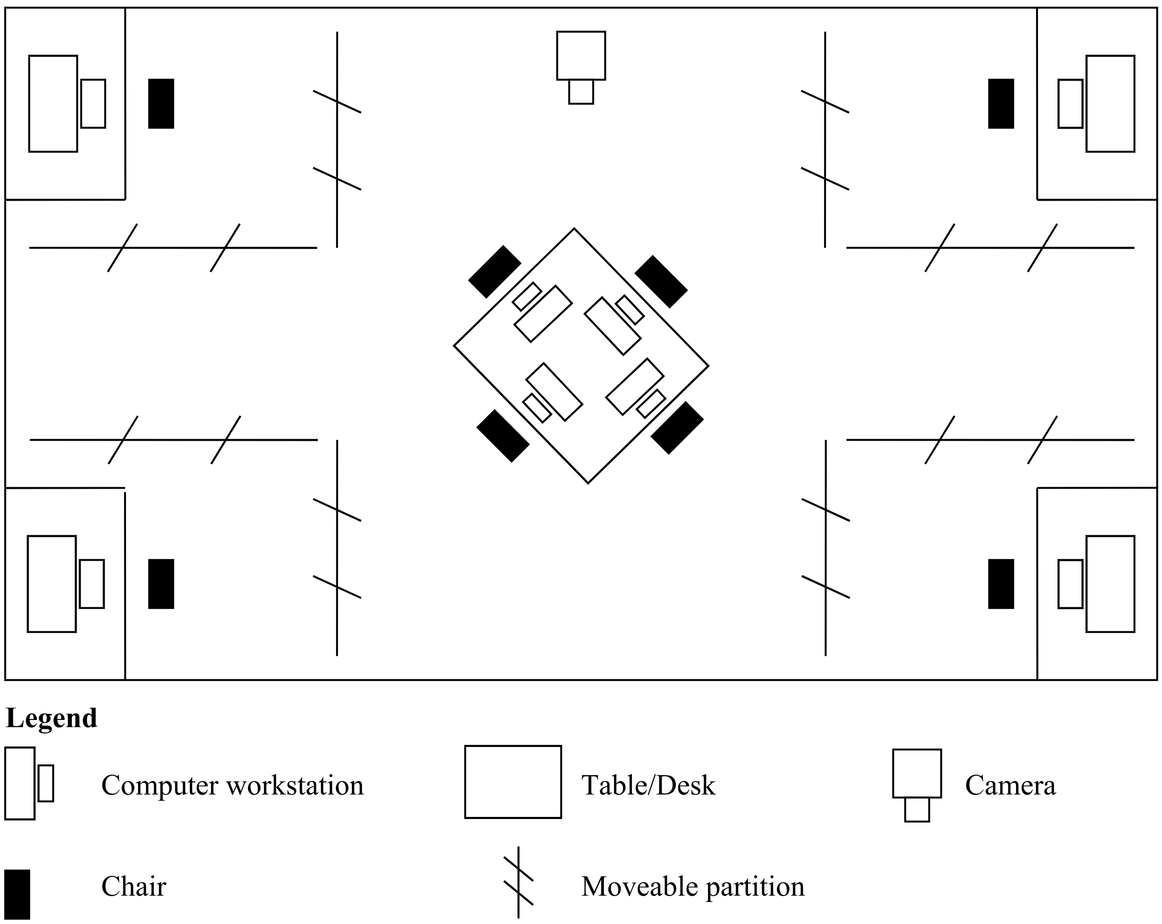

Figure 1: *Laboratory layout.*

Assignment to a higher-order group was based on the computer at which the participant sat. However, as mentioned earlier, participants were not made aware of this and there was no external indication that would differentiate the computers or higher-order groups. Once all of the participants had arrived, they were asked to each complete a demographic questionnaire (see Annex C), along with a series of personality questionnaires. The personality questionnaires that

[5] While there were four available researchers (two male, two female) only one researcher was present during any experimental session.

were completed by participants served to bolster the cover story that participants were allocated to their group (Earth, Air, Fire, or Water) based on the similarity of their personality profile to those of other members of the group.[6] All of the questionnaires were completed on the laptops using MediaLab software (Empirisoft, 2008).

Upon completion of the personality questionnaires, participants received the following message:

> Each participant in the session has been assigned to one of four groups (Earth, Air, Fire, or Water[7]). Because your responses to the preceding measures most closely matched the _______ [Earth/Air/Fire/Water] group, you have been placed with that group. In each session of the study, there is one representative from each of the four groups. You may only refer to other team members from this session by their group name. The points you score in this session will be combined with the scores of the other _______ [Earth/Air/Fire/Water] members from other sessions to create a total score for the _______ [Earth/Air/Fire/Water] group. The group with the highest score at the end of the study will receive a bonus prize of $500. The proportion of the prize that you receive will be based on your contribution to the group score (i.e., the more points you contribute to the group score, the larger your proportion of the prize money).

Participants were led to believe that their assignment to a higher-order group (Earth, Air, Fire, Water) was based on their responses to the personality questionnaires in an effort to create a connection between themselves and the other members of their higher-order group that they would not know. By creating a group with whom they felt they had commonalities, we hoped to create an alternative loyalty, akin to loyalty for a home organization, beyond a loyalty for the meta-team members with whom they were participating in the current study.

After reading the categorization paragraph, participants were introduced to the problem-solving task, which was carried out using the Planning Task for Teams (PLATT) program (TNO, 2009). The PLATT program is a networked program that allows participants to send and receive email messages within the network and to post information to a shared postings board. Participants were trained on the use of the PLATT program and given a practice scenario prior to the experimental sessions. The practice session was based on the board game “Clue” in that participants were asked to identify *who* the killer was, *where* the murder took place, and *what* murder weapon was used.

For the experimental sessions, participants were informed that the task would be very similar to the “Clue” game they had just played. Rather than acting as a detective to identify the killer, the

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[6] These measures included an Instrument to Measure Social Value Orientation (Van Lange, Otten, De Bruin, & Joireman, 1997), the Need to Belong Scale (Leary, Kelly, Cottrell, & Schreindorfer, 2007), the Marlowe-Crowne Social Desirability Scale (Crowne & Marlowe, 1960), the Regulatory Focus Scale (Lockwood, Jordan, & Kunda, 2002), Uncertainty Response Scale: Emotional Uncertainty Subscale (Greco & Roger, 2001), the Narcissistic Personality Inventory: Short Version (Ames, Rose, & Anderson, 2006), and the Mini-Markers measure of the Big Five (Saucier, 1994). Although we did not analyze the personality data for this report, analysis of such data may be conducted in future work.

[7] The group names were chosen, in part, because it was convenient, since problems were created with the idea of having four team members and there are four elements. They were also, in part, chosen because they could be thought of as representing the different elements within the CAF (Earth = Army, Air = Air Force, Navy = Water) and emergency services (Fire) with whom the CAF often collaborate.

murder weapon, and the crime scene, they were asked to imagine themselves as information analysts working for a counter-terrorism agency. Their task was to identify the details of an impending terrorist attack, thus identifying *who* was attacking, *when* they were attacking, *where* they were attacking (i.e., the country), and *what* they were attacking (i.e., the specific target within the country). Prior to each scenario, participants received an organizing sheet specific to that scenario that listed all of the possible groups involved, target countries, targets within the country, and dates. They then received six emails, or "factoids," from "Headquarters" (see Annex D to view the organizing sheets and a list of factoids). Three of the factoids were key to solving the problem and three were noise factoids that, while they did not conflict with the key factoids, did not aid in identifying the correct solution. Key factoids could either be used to eliminate (e.g., "All the members of the Azure group are now in custody"), or to specify information (e.g., "Venus is planning something in April on the anniversary of her father's death"). As is standard practice in research that assesses the interactions of teams (see Mesmer-Magnus et al., 2011), participants received both shared and unshared factoids. Of the six factoids received, four were unique to the participant and two (one key and one noise factoid) were shared amongst all the meta-team members. However, the information that some of the factoids were shared amongst all the meta-team members was not offered to participants, and no participants asked the researcher whether any of the factoids were shared. Knowing (or not knowing) that some of the factoids were shared could have influenced interactions within the team. Believing that one is the only person with access to information could impact how one interacts with others. For the most part, however, this was only true for the first round because if participants interacted during round one, they discovered the shared information.

Participants were informed that they would play between one and eight rounds. Each round consisted of one scenario and lasted 15 minutes or until a correct response was submitted. In fact, all meta-teams played five rounds. All scenarios were counterbalanced across meta-teams.

Participants were also informed of the following scoring structure prior to their first round: if one person submitted a correct answer, then that individual would receive 25 points; if two or more members submitted a correct response within 45 seconds of each other, then that response would be considered a collaborative response and each person submitting the correct response within that timeframe would receive 5 points; if no one submitted a correct response within the allotted time, then all meta-team members would be penalized 10 points. The scoring structure was created to ensure that: 1) there was a temptation to solve the problem alone as it meant receiving significantly more points than did solving the problem as part of a team; and 2) there was an incentive to have someone solve the problem as not solving the problem would lead to a substantial penalty.

A 2-minute warning was sent out via email from Headquarters that reminded participants of the penalty for not solving the problem. All responses had to be submitted to Headquarters electronically. Participants received electronic feedback to submitted responses; however, the feedback only indicated whether the entire answer was correct or incorrect. No feedback was provided with regards to specific components of the response. Thus if part of the answer was incorrect or was missing, the entire submission would be deemed incorrect.

Participants in the Dc were asked to communicate with other meta-team members only electronically and not to call out to each other in order to mimic more closely a distributed team that could not easily communicate verbally. Participants in the FtFc, on the other hand, were informed that they could either communicate verbally or electronically. All participants were asked to refer to other participants (meta-team members) only by their group name (Earth, Air, Fire, Water). All FtFc sessions were videotaped and audio-taped for transcription purposes.

Upon completion of the fifth scenario, participants were informed that there were no more scenarios and were asked to complete a PIQ (see Annex E). Upon completion of the PIQ, participants were debriefed with regard to the purpose of the study and were asked if they had any questions. After debriefing, participants completed pay forms and were presented with contact information for the principal investigators and both the DRDC Toronto and York University Human Research Ethics Committees.

2.3 Quantitative measures

2.3.1 Post-Interaction Questionnaire (PIQ)

Upon completion of the problem-solving task, participants completed the PIQ. The PIQ asked participants to rate each of the other meta-team members on their honesty, likeability, cooperativeness, helpfulness, and their willingness to work with that individual in the future on a scale of *1* (least positive) to *7* (most positive). Thus, each participant was rated three times on each of these items, once by each of the other meta-team members (they did not rate themselves). The five items of the PIQ were found to have high internal consistency ($\alpha = .94$); therefore, they were summed to create an overall PIQ score. The other three meta-team members' ratings for each participant were found to be significantly correlated with each other ($.30 < r < .42$; $p \leq .001$). In other words, participants were viewed somewhat consistently by all of their meta-teammates. These three scores, therefore, were averaged to create an overall "others' liking" score.

2.3.2 Difficulty

A measure of the difficulty of a particular scenario was created by counting the number of times (out of 30) that the problem was solved across the 30 meta-teams. The scenarios were then ranked and labeled from *1* (least difficult) to *5* (most difficult).

2.4 Qualitative measures

The interactions of the 30 meta-teams within the sessions provided two kinds of qualitative behavioural data for analysis: electronic and verbal communications.

Firstly, the PLATT program recorded each action taken by each participant and created a log file, which was then edited to include only non-redundant information and actions taken. For example, the log file recorded when a message was sent, when that same message was received by the intended recipient, when the recipient opened the message, and any time the message was subsequently read. The edited log file used for data analysis included only sent message information (i.e., sent, forwarded, or reply emails, and posts to the postings board).

Secondly, to assess the verbal interactions of the FtFc participants, all sessions were videotaped, with accompanying audio-tape, and transcribed. The interactions from one meta-team were unable to be transcribed since the participants whispered too low to be heard. Therefore, this group was excluded from any analyses that included behavioural data because the PLATT log files by themselves did not fully represent the interactions of the participants in this team and, due to the lack of transcript, their verbal communications could not be accurately coded. However, the data from this session were included where behavioural factors were not considered.

NVivo8 (QSR International, 2008), a qualitative research software package, was used to identify and categorize interactions amongst participants. Analysis involved two stages. The first stage involved a preliminary analysis of the data using NVivo8 in order to determine the structure of the coding scheme. Three of the co-authors met to discuss, debate, and reach consensus on the coding scheme, resulting in a coding scheme that was imported into NVivo8 and used in the second stage of analysis. The main categories included in this coding scheme were Answers submitted, Offers of information, Requests for information, Offers of speculation, Requests for speculation, Confirmation, Negation, Clarification question, Clarification response, Cooperation/Strategizing, Uninformative response, Rule clarification, and Miscellaneous (see Annex F for a full explanation of the coding scheme used). In the second stage of analysis, the first author analyzed all 30 sessions, while one of the co-authors analyzed 19 sessions and another co-author analyzed the other 11 sessions. Thus, each session was coded by two raters. The separate "projects" of each rater were merged into one project and a coding comparison was conducted. Any disagreements between coders was discussed and resolved so that 100% agreement was achieved prior to any further data analysis.

The number of each type of interaction by each participant was totalled and this was divided by the overall number of interactions to create a proportional score. Proportional scores were used rather than overall counts so that a comparison could be made between the two conditions with regard to how participants in each condition spent their time interacting. By virtue of the ease of communication, FtFc participants had a greater overall number of interactions ($M = 44.19$, $SD = 28.69$) than Dc participants ($M = 11.48$, $SD = 7.10$); however, it is the pattern of this interaction that is important for the present study, as the hypotheses make specific predictions about how the pattern of interactions, not the number of interactions, would relate to problem-solving.

2.5 Data preparation and screening

As an initial step in data analysis, the data were assessed for missing values, outliers, skewness and kurtosis, and distributions.

With respect to missing data, 5 participants out of 120 had missing qualitative data. One participant in the Dc had only one interaction during the entire five-round session. As previously mentioned, one team of 4 participants in the FtFc did not speak loudly enough to be understood and their interactions, therefore, could not be transcribed or subsequently coded. These 5 participants, therefore, were excluded from any analyses that involved the qualitative behavioural data due to a lack of data.

When assessing the PIQ ratings and the behavioural variables summed across the five rounds, 16 univariate outliers (i.e., $z > |3.29|$, $p < .001$) were converted to the next most extreme case, which is a commonly suggested measure for dealing with univariate outliers (e.g., Kline, 1998).

Next, the univariate skewness and kurtosis of the data were assessed. The recommended values for significance of skewness and kurtosis are |2| and |7|, respectively (West et al., 1995). Violations of normality greater than these suggested cutoffs have been shown to affect the interpretations made in the process of multivariate analyses (Tabachnick & Fidell, 2001). None of the PIQ ratings or the behavioural variables summed across the five rounds fell outside of the range of normally distributed data, and therefore, no transformations were performed.

While the behavioural variables were expected to be normally distributed over the course of the five rounds, for individual rounds, the behavioural indicators were not expected to be normally distributed. Some types of interactions (e.g., Negations, Untrue/Partial Truths) happened infrequently over all the rounds and might not be expected to happen in each round. Because the indicators denoted the percentage of interactions spent in a particular type of interaction, it was predictable that the interactions of some participants would be dominated by one type of interaction at the expense of other types of interactions. While this might even out over the course of the five rounds as participants adjust their interaction strategies, the pattern of interactions when assessed per round were not normally distributed. For example, one participant might have used the strategy of waiting for others to share information in the early rounds, and their interactions might have been dominated by answer submissions for that round, with little sharing or requesting of information themselves. However, as they discovered that this strategy was not particularly effective, they might have begun to distribute their interactions between sharing information, requesting information and submitting answers. While this pattern might have resulted in skewed data when assessed per round, it informed the data with regards to different strategies used by different participants. Therefore, no data cleanup was performed on the data per round, neither to reduce outliers nor to normalize the data. However, the distribution of the data was considered when selecting data analysis tests (to be discussed).

3 Results

3.1 Descriptive statistics

Table 1 provides the descriptive statistics and the intercorrelations among the PIQ and the overall variables. As can be seen, there was a large number of significant correlations within the data. However, for the purposes of this report, only the findings that are most directly relevant to the hypotheses will be discussed here. From this table we see that participants' ratings of other meta-team members were similar for the most part, as evidenced by the significant correlation between average rating of others (AO), highest ratings (HR) and lowest ratings (LR). Additionally, there was a significant positive correlation between how participants rated their meta-teammates (AO) and how those teammates rated them (Other's Rating, or OR). There was also a strong positive correlation between the number of interactions undertaken by any one participant, their ratings of their team members, and their team members' ratings of that participant.

While Offers of Information (OI) was not correlated with any of the liking variables, Offers of Speculation (OS) was significantly positively correlated with both how participants rated their teammates and how their teammates rated them. Finally, in terms of liking, there was a significant positive correlation between how others rated a participant and the highest, but not the lowest, rating that they gave to their teammates. In other words, the feelings of liking or disliking appeared to be mutual, when considering highest ratings. If a participant was well liked, then that participant rated at least one other person highly as well. If a participant was not well liked, on the other hand, then that participant tended to not like any of their teammates, resulting in a low HR score.

The total number of correct responses was positively correlated with AO, HR, OR, Total Interactions (TI), Cooperation/Strategizing (C/S), Confirmations (Con.), and Negations (Neg.). Therefore, the more participants liked their meta-teammates overall, or at least one other person on their team, the more they were liked by their team, the more "talkative" they were, the more they strategized, and the more they provided feedback to other team members through confirmations and negations, the more problems they were likely to solve. Interestingly, OI was negatively correlated with the number of correct responses. Taken together, these results indicate that effective problem solving is related to open discussion. However, it appears that this discussion needs to be targeted. Simply providing a deluge of information will not effectively help in the problem solving process. Rather, the more effective approach appeared to be one of strategizing and reasoning through the information (via confirmations and negations).

One factor that did not contribute to correct responding was answer submissions, or Answers (Ans.). There was no significant correlation between the number of answers a participant submitted and how likely they were to be correct.

Table 1: *Summary of intercorrelations, means, and standard deviations for scores on the PIQ, behavioural and performance variables.*

Variable	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*
1. AO	--	.72**†	.79**†	.18*	.46**	-.23*	.43*	.37*	.16	-.15	.24**	-.26**	.08	.45**	.11	-.30	-.25**	.24**
2. HR		--	.21*†	.27**†	.33**	-.18	.29**	.31**	.31**	-.06	.12	-.24**	-.06	.29**	.07	-.23*	-.12	.34**†
3. LR			--	.02†	.32**	-.17	.33**	.26**	-.06	-.11	.19*	-.11	.09	.35**	.04	-.26**	-.19*	.05†
4. OR				--	.60**	-.49**	.27**	.31**	.28**	-.02	.32**	-.19*	.12	.52**	.24*	-.25**	-.04	.21*†
5. TI					--	-.50**	.60**	.59**	.37**	-.37**	.46**	-.25**	.17	.68**	.26**	-.26**	-.21*	.27**
6. Ans.						--	-.35**	-.37**	-.40**	-.07	-.54**	.03	-.23*	-.51**	-.25**	.10	-.04	-.07
7. CQ							--	.68**	.20*	-.25**	.19*	-.34**	.02	.44**	.23*	-.19*	-.14	.11
8. CR								--	.22*	-.27**	.25**	-.34**	-.04	.51**	.23*	-.17	-.15	.16
9. C/S									--	-.15	.18	-.30**	-.04	.36**	.21*	-.14	-.10	.37**
10. OI										--	-.29**	-.14	-.35**	-.19*	-.06	-.18	.05	-.20*
11. OS											--	-.37**	.30**	.47**	.30**	-.16	-.39**	.06
12. RI												--	-.01	-.46**	-.33**	.30**	.42**	-.09
13. RS													--	.11	.04	-.08	-.07	-.12
14. Con.														--	.32**	-.27**	-.30**	.26**
15. Neg.															--	-.21*	-.28**	.29**
16. U/P																--	.16	-.15
17. UR																	--	-.12
18. TC																		--
M	2.93	5.75	3.87	4.85	115.57	17.73	3.50	3.38	7.50	22.94	15.67	13.03	6.50	3.85	0.89	1.76	2.45	0.97
SD	0.86	0.89	1.26	0.99	89.24	15.00	4.42	4.45	6.72	12.34	10.57	11.01	4.99	4.20	1.35	2.49	2.73	0.98

Note. $N = 115$, unless otherwise indicated; † $N = 120$; *$p < .05$; **$p < .01$; AO = Average Others; HR = Highest Rating; LR = Lowest Rating; OR = Others' Rating; TI = Total Interactions; Ans. = Answers; CQ = Clarification Question; CR = Clarification Response; C/S = Cooperation/Strategizing; OI = Offers of Information; OS = Offers of Speculation; RI = Requests for Information; RS = Requests for Speculation; Con. = Confirmations; Neg. = Negations; U/P = Untrue/Partial Truth; UR = Uninformative Response; TC = Total Correct; *M* = Mean; *SD* = Standard Deviation.

3.2 Condition comparisons

3.2.1 Hypothesis 1

As expected, there was no significant difference in the number of problems solved by the FtFc teams (40) and the Dc teams (38) ($\chi^2 1 = .11$, $p > .05$; see Table 2).[8] However, when we examine how teams solved problems in these two conditions (i.e., as a group or individually), we also see that there was no statistical difference between Dc teams and FtFc teams in individual problem solving ($\chi^2 1 = 2.31$, $p > .05$), whereas (as was predicted) FtFc teams were over three times more likely than Dc teams to solve a problem as a group ($\chi^2 1 = 6.71$, $p < .01$) (overall $\chi^2 2 = 7.24$, $p < .05$).

Table 2: *Problem solving as a function of condition.*

	FtFc	Dc	Total
Not Solved	34	36	70
Solved	40	38	78
-By an individual	24	33	57
-By more than one person	16	5	21

3.2.2 Hypothesis 2

It was hypothesized that face-to-face condition participants would be viewed more positively by members of their meta-team and would view their meta-team more positively than would distributed condition participants. This hypothesis was assessed in several ways. First, the average of other meta-team members' ratings (OR) of a participant was evaluated. As predicted, participants in the FtFc ($M = 5.14$, $SD = 1.11$) were viewed more positively on average by their meta-teammates than were participants in the Dc ($M = 4.57$, $SD = 0.76$; $t_{118} = 3.24$, $p < .01$).

We also assessed how a participant viewed other members of their meta-team. First, we calculated the mean of participants' ratings of their meta-team members that we called "Average Others" (AO). An independent samples t-test indicated that those in the FtFc ($M = 5.14$, $SD = 0.91$) liked their meta-teammates more than did those in the Dc ($M = 4.57$, $SD = 0.69$; $t_{118} = 3.86$, $p < .001$). However, by averaging the scores, it is unclear whether the difference in sentiment between the two conditions is a result of negative feelings amongst the Dc participants or positive feelings amongst the FtFc participants. In order to differentiate the direction of the sentiment, we went on to assess the lowest rating (LR) and the highest rating (HR) given by a participant to their meta-teammates. Before conducting the analysis, it is important to understand exactly what is being measured by the LR and HR variables. While LR may appear to measure how much a participant disliked their meta-teammates and HR may appear to measure how much a participant liked their meta-teammates, the opposite may, in fact, be true. This is because a high rating (HR) may simply reflect the fact that a participant has rated one of their meta-teammates highly in terms of liking, while at the same time has given low ratings to their other two meta-teammates.

[8] Due to experimenter/technical errors, two rounds (one Dc and one FtFc) had to be terminated early. As these rounds did not portray an accurate picture of problem solving, they were eliminated from any further analysis.

In other words, while a participant may have rated one other team member 7 in terms of liking, they could have rated the other two team members 1 or 7. While a high rating for HR does not indicate how one felt about these other two team members, a low rating for HR means that the entire team was not very well liked by the participant. For example, if the highest rating a person gave another team member was 2, then it reflects a lack of liking across all of the team members. Just as HR was an indicator of a potential lack of positivity in this example, LR may be an indicator of the presence of positivity. While a rating of 1 on this scale (as a lowest rating) may mean that they disliked one person or that they disliked everyone, if the lowest rating (LR) was 6, then there were no negative feelings towards anyone in the group. Turning now to the analysis of these variables, there was no difference between FtFc ($M = 4.05$, $SD = 1.51$) and Dc ($M = 3.69$, $SD = 0.91$) participants on LR ($t_{118} = 1.59$, $p = .11$). There was, however, a significant difference between FtFc ($M = 6.05$, $SD = 0.79$) and Dc ($M = 5.45$, $SD = 0.88$) participants on HR ($t_{118} = 3.92$, $p < .001$). In other words, while those in the distributed condition and those in the face-to-face condition had similar positive feelings towards their meta-teammates (LR), those in the distributed condition participants liked their meta-teammates relatively less than did face-to-face condition participants (HR). This is consistent with the finding that distributed condition participants both viewed and were viewed by their meta-teammates less positively than was the case for face-to-face condition participants.

3.2.3 Hypothesis 3

Hypothesis 3 concerned the differential pattern of interaction distribution across communication conditions. As discussed earlier, participants in the Dc were expected to spend a greater proportion of their time submitting answers, requesting information, and offering information, than participants in the FtFc. Further, participants in the FtFc were expected to spend a greater proportion of their time discussing strategies, offering speculations, requesting speculations, and clarifying, than participants in the Dc. Due to the nature of the behavioural data (i.e., count data), standard tests for comparisons, which assume a normal distribution of scores (e.g., *t*-tests), were inappropriate. Instead, nonparametric tests, which do not assume a normal distribution of scores, were used. Rather than assessing *M*s and *SD*s, these statistics assess the rank order of the Median (*Mdn*) across groups. The specific test used in this study for the between-groups comparison of interactions was a *z* score, calculated from the Mann-Whitney *U* statistic (z_U). Table 3 lists the *Mdn,* Inter-quartile range (*IQR*)*,* and test statistics for comparing interactions across groups.

As predicted, the pattern of interactions differed across conditions. Supporting Hypothesis 3a, it was found that more participants in the Dc, compared to the FtFc, spent a greater proportion of their interactions submitting answers ($z_U = -4.89$, $p < .001$), requesting information ($z_U = -3.80$, $p < .001$), and offering information ($z_U = -2.49$, $p < .05$). Further, as predicted in Hypothesis 3b, within the FtFc, more participants spent a greater proportion of their interactions cooperating or discussing strategy ($z_U = -5.92$, $p < .001$), offering speculations ($z_U = -3.79$, $p < .001$), and asking ($z_U = -8.58$, $p < .001$) and responding to clarification questions ($z_U = -9.34$, $p < .001$) than did the Dc participants. Contrary to Hypothesis 3b, however, there was no difference between conditions on the proportion of interactions that were spent on requesting speculations ($z_U = -0.19$, $p = n.s.$). More FtFc participants also spent a greater proportion of their interactions confirming ($z_U = -7.16$, $p < .001$) and negating ($z_U = -5.28$, $p < .001$) other team members compared to Dc participants. No hypotheses had been made about a differential distribution of these variables.

Table 3: *Comparison of percentage of interactions within behavioural indicators across conditions.*

Categories of interactions	FtFc		Dc		z_U	*p*
	Mdn	**IQR**	**Mdn**	**IQR**		
Answers Submitted (Ans.)	8.16	3.63, 14.09	22.73	10.53, 34.37	-4.89	<.001
Offers of Information (OI)	19.20	12.27, 25.20	23.81	15.79, 34.29	-2.49	<.05
Offers of Speculation (OS)	18.71	13.34, 25.51	10.71	3.12, 17.39	-3.79	<.001
Requests for Information (RI)	6.34	4.21, 10.34	17.57	5.26, 30.77	-3.80	<.001
Requests for Speculation (RS)	6.21	3.00, 8.66	5.88	2.08. 10.94	-0.19	*n.s.*
Untrue/Partial Truth (U/P)	0.43	.00, 1.70	1.45	.00, 3.57	-1.28	*n.s.*
Clarification Questions (CQ)	5.76	2.78, 9.67	.00	.00, .00	-8.58	<.001
Clarification Responses (CR)	5.48	3.44, 8.92	.00	.00, .00	-9.34	<.001
Confirmations (Con.)	6.12	3.90, 8.82	.00	.00, 2.13	-7.16	<.001
Negations (Neg.)	1.01	.00, 2.16	.00	.00, .00	-5.28	<.001
Cooperation/Strategizing (C/S)	10.51	5.84, 17.55	2.86	.00, 6.25	-5.92	<.001
Uninformative Response (UR)	1.40	0.80, 2.35	1.90	.00, 5.36	-1.02	*n.s.*

Note. $N = 56$ for FtFc; $N = 59$ for Dc.

3.3 Multilevel Modeling (MLM)

In order to assess the hypotheses regarding the factors that might lead to successful problem solving, multilevel modeling (MLM) was employed using the MLwiN software (Rasbash, Browne, Healy, Cameron, & Charlton, 2011). MLM is comparable to a regression analysis. However, by using MLM, the natural nested hierarchical structure of the data is retained. For instance, within the current study, not only is data analyzed at the level of the individual team member as it would be in a typical regression analysis, but the rounds are nested within the team member and team members are nested within the teams (see Figure 2). In this way we can account, for example, for the similarity of interactions or attitudes amongst meta-team members within the same meta-team. Ignoring the nested structure of the data underestimates the standard error and overestimates the significance of the coefficients leading to "*alpha inflation*" (Cohen, Cohen, West, & Aiken, 2003; p. 537).

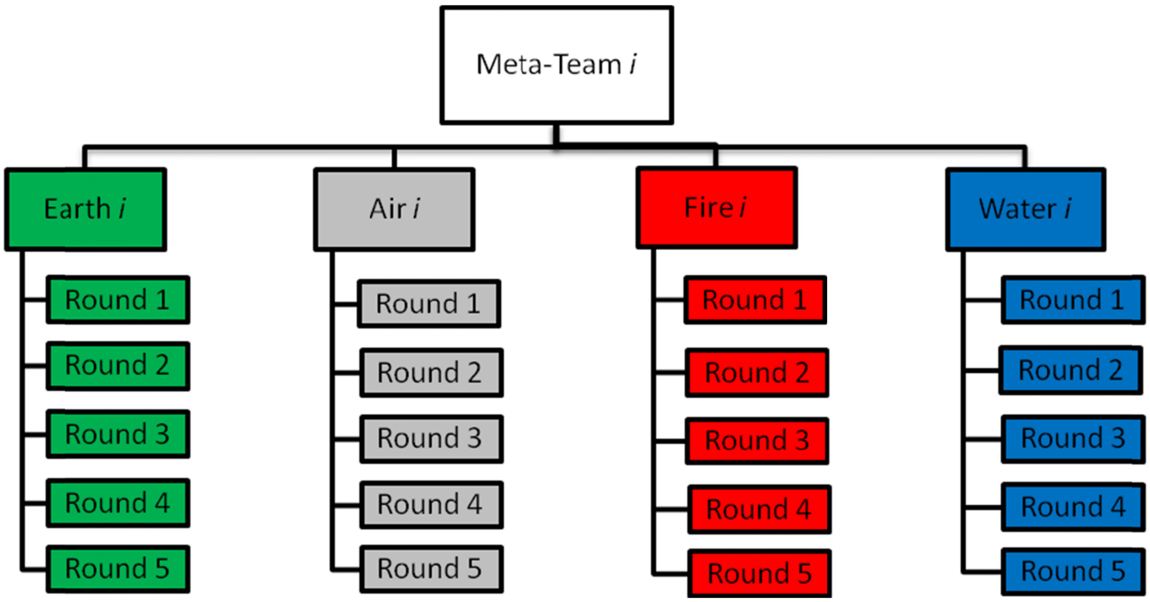

***Figure 2:** Illustration of a nested multilevel model for a meta-team.*

3.3.1 Hypothesis 4

Hypothesis 4 was concerned with the role of collaboration, specifically certain kinds of information sharing, in successful problem-solving performance. The dependent variable (DV) that was used to assess this hypothesis was successful problem solution in each round. This was coded as 0 when the problem was not solved and 1 when the problem was solved. Due to the binary nature of the response variable, the criterion variable was the *probability* of solving the problem versus not solving the problem. This would be comparable to a standard logistic regression, where the regression coefficients are part of a link function that ensure that predicted probabilities lie between 0 and 1 (Rasbash, Steele, Browne, & Goldstein, 2009). Specifically, in this study, a logit link function, which is the default link function, was used (see Equation 1).

$$\text{logit}(\pi_{ij}) = \log\left(\frac{\pi_i}{1-\pi_i}\right) = \beta_0 + \beta_i x_j \qquad (1)$$

By taking the exponential of the coefficients, we can see the multiplicative effects of a unit increase in x on the probability of the DV.

3.3.1.1 Hypothesis 4a

3.3.1.1.1 Binomial analysis

To assess the impact of the qualitative behavioural factors on the probability of solving the problem, a binomial analysis was conducted that included Uninformative Response (UR) (centered), Untrue/Partial Truth (U/P) (centered), and C/S (centered), while controlling for problem difficulty. To assess whether the relationships between each of these variables and the probability of solving the problem were the same across conditions, the condition, as well as the interactions between condition and each of the predictor variables, was also included in the model. Therefore, the following model was fit to the data (see Equation 2).

$$\begin{aligned}\text{logit}(\pi_{ijk}) = \beta_0\text{constant} + \beta_1\text{difficulty} + \beta_2\text{condition} + \beta_3\text{UR} \\ + \beta_4\text{U/P} + \beta_5\text{C/S} + \beta_6(\text{condition} \times \text{UR}) \\ + \beta_7(\text{condition} \times \text{U/P}) + \beta_8(\text{condition} \times \text{C/S})\end{aligned} \quad (2)$$

As noted earlier, one meta-team (4 team members × 5 rounds) was not included in any of the behavioural analyses because it was not possible to transcribe their interactions due to low audio volume. In addition, one round for one meta-team (4 team members × 1 round) was removed because the round was ended early as a result of experimenter error. While a second round also experienced this issue, this round occurred within the meta-team that was removed due to incomplete transcription. Finally one meta-team member (1 meta-team member × 5 rounds) was eliminated because, as mentioned earlier, h/she engaged in one interaction across all five rounds.

The results of this analysis indicate that none of the interactions were significant, and therefore, the impact of UR, U/P, and C/S was not moderated by whether the participants were face-to-face or used CMC. The interaction terms as well as the condition term were, therefore, removed from the equation and the model was reanalyzed. The resulting model is shown in Table 4.

Table 4: *Coefficient estimates and standard errors of the estimate for binomial model predicting problem solving from UR, U/P, and C/S.*

Variable	***ß***	***SE***	***z = ß/SE***	***p***	e^{β}
Constant	-1.58	0.12	-13.17	<.05	0.20
Difficulty	-0.40	0.11	-3.64	<.05	0.67
UR	-0.64	0.20	-3.20	<.05	0.53
U/P	0.03	0.11	0.27	*n.s.*	1.03
C/S	0.25	0.10	2.50	< .05	1.28

Note. N = 571 [(30 teams × 4 team members × 5 rounds) – (4 team members × 5 rounds) – (4 team members × 1 round) – (1 team member × 5 rounds)]; * $p < .05$.

As can be seen from these results, when controlling for the difficulty of the problem, a 1 SD increase in UR made it 0.53 times as likely (i.e., approximately half as likely) that the problem would be solved, while a similar increase in C/S made it 1.28 times more likely that the problem would be solved. U/P had no impact on the probability of solving the problem. Thus, regardless of whether participants were in the face-to-face condition or the distributed condition, cooperation and strategizing was associated with the best performance (i.e., the highest probability of solving the problem), thus partially supporting Hypothesis 4a.

3.3.1.1.2 Multinomial analysis

A second analysis was conducted to assess the probability of solving the problem either alone or as part of a team, versus not solving the problem at all. This analysis used a multinomial distribution of the criterion variable. Using the multinomial distribution, two regression equations were fit to the data, one for solving alone and one for solving as part of a team. Each probability was contrasted with not solving the problem. Once again, none of the interaction terms that included condition were significant; therefore, these terms were removed from the model. Table 5 lists the results of the two equations' fit to the data after removing any non-significant terms.

Table 5: *Coefficient estimates and standard errors of the estimate for multinomial model predicting specific type of problem solving from condition, UR, U/P, and C/S.*

Variable	Solving alone			Solving as part of a team		
	ß	***SE***	e^{β}	***ß***	***SE***	e^{β}
Constant	-2.21*	0.16	0.11	-2.11*	0.23	0.12
Difficulty	-0.39*	0.15	0.68	-0.40*	0.15	0.67
Condition	--	--	--	0.94*	0.35	2.56
UR	-0.50*	0.23	0.61	-0.92*	0.39	0.40
U/P	0.19†	0.11	1.21	--	--	--
C/S	--	--	--	0.36*	0.13	1.43

Note. *N* = 571 [(30 teams × 4 team members × 5 rounds) – (4 team members × 5 rounds) – (4 team members × 1 round) – (1 team member × 5 rounds)]; * $p < .05$; † $p < .10$.

When predicting the probability of solving the problem alone, as opposed to not solving the problem, both the condition and C/S were not significant predictors and were therefore removed from the final model. After controlling for the difficulty of the problem, UR significantly decreased this probability while U/P increased it, though marginally. A 1 *SD* increase in UR made it 0.61 times as likely that the problem would be solved alone versus not being solved at all and the same increase in U/P made it 1.21 times more likely that the problem would be solved.

When predicting the probability of solving the problem as part of a team as opposed to not solving the problem at all, U/P statements did not predict problem solving. Again we see that after controlling for the difficulty of the problem, increases in UR decreased problem solving probability. On the other hand, increases in C/S behaviour increased this probability, as did being part of the FtFc. A 1 *SD* increase in UR made it 0.40 times as likely that a participant would be part of a team solution. On the other hand, a 1 *SD* increase in C/S made it 1.43 times more likely that the participant would solve the problem as part of a team versus not solving the problem at all. Finally, being in the FtFc increased the probability of solving the problem as part of a team by a factor of 2.56.

In summary, after controlling for the difficulty of the problem, providing uninformative responses decreased the likelihood of solving the problem alone. However, in contrast to Hypothesis 4a, providing untrue or partially true information to one's meta-teammates increased this probability (though only marginally). On the other hand, after controlling for the difficulty of the problem, solving the problem as a team was much more likely in the face-to-face condition and when more cooperative/strategizing comments were made. As with solving the problem alone, the likelihood of solving the problem as a team was significantly decreased by uninformative responses.

3.3.1.2 Hypotheses 4b & 4c

3.3.1.2.1 Binomial analysis

To assess the differing impact on problem solving of offering and requesting information versus speculation across conditions, two binomial analyses were conducted. One equation assessed the impact of offers of and requests for information (each centered), while the other assessed the impact of offers of and requests for speculation (each centered). Both equations followed the same pattern (see Equation 3).

$$\begin{aligned}\mathrm{logit}(\pi_{ijk}) = {} & \beta_0\mathrm{constant} + \beta_1\mathrm{difficulty} + \beta_2\mathrm{condition} + \beta_3\mathrm{OI/OS} \\ & + \beta_4\mathrm{RI/RS} + \beta_5(\mathrm{condition} \times \mathrm{OI/OS}) + \beta_6(\mathrm{condition} \times \mathrm{UR}) \\ & + \beta_7(\mathrm{condition} \times \mathrm{U/P}) + \beta_8(\mathrm{condition} \times \mathrm{C/S})\end{aligned} \tag{3}$$

Contrary to Hypothesis 4c, neither of the speculation variables or their various interactions terms were significant predictors of problem solving.[9] For the model predicting probability of problem solving from the information terms (offers and requests), the three-way condition × OI × RI interaction was not significant and was, therefore, removed. The equation was rerun and the results of this re-analysis are shown in Table 6. After controlling for the difficulty of the problem, there were significant OI × RI and condition × RI interactions and a marginally significant condition × OI interaction.

Table 6: *Coefficient estimates and standard errors of the estimate for binomial model predicting problem solving from condition, OI, and RI.*

Variable	*ß*	*SE*	*z = ß/SE*	*p*	*eß*
Constant	-1.91	0.19	-10.05	< .01	0.15
Difficulty	-0.33	0.08	-4.12	< .01	0.72
Condition	0.38	0.25	1.52	*n.s.*	1.47
OI	-0.06	0.16	-0.37	*n.s.*	0.94
RI	-0.07	0.16	-0.44	*n.s.*	0.93
Condition × OI	-0.42	0.24	-1.75	< .10	0.66
Condition × RI	-0.63	0.31	-2.03	< .05	0.53
OI × RI	-0.43	0.15	-2.87	< .01	0.65

Note. N = 571 [(30 teams × 4 team members × 5 rounds) – (4 team members × 5 rounds) – (4 team members × 1 round) – (1 team member × 5 rounds)]

To probe the interactions, an online tool by Preacher, Curran, and Bauer (2010) was used which, after centering both the OI and RI variables at 1 SD above and below the mean, assessed simple slopes across conditions (see Aiken & West, 1991; Preacher, Curran, & Bauer, 2006). Turning first to the OI × RI interaction (see Figure 3), we find that, while the slope of OI is not significant

[9] The variables were removed in a series of steps, starting with the three-way interaction, then removing the least significant two-way interactions, and finally removing the least significant main effects. A detailed description of these steps is not included here because they did not change the pattern of results.

at low levels of RI ($z = 1.12$, $p = .26$), there is a strong negative relationship between OI and the probability of solving the problem at high levels of RI ($z = -2.61$, $p < .01$). In other words, across conditions, participants who spent a great deal of their interactions both asking and offering information had the lowest probability of solving the problem when compared to any other combination of offers of and requests for information.

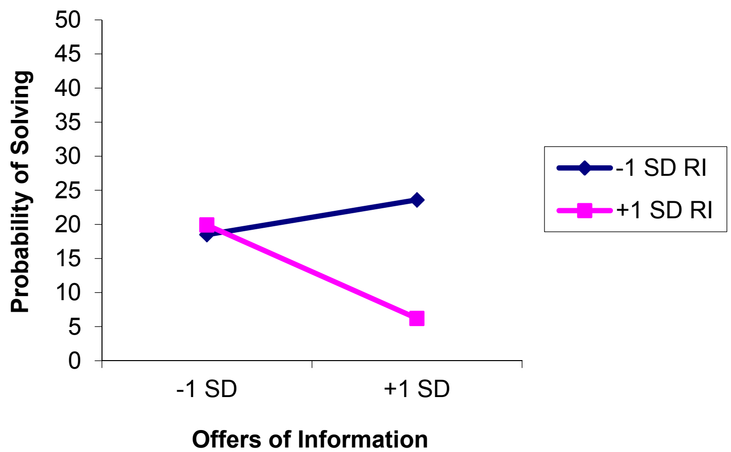

Figure 3: *Probability of solving a problem as a function of offers of and requests for information.*

In the condition × OI interaction (see Figure 4), we see that, contrary to Hypothesis 4b,there was no relationship between OI and probability of correctly solving the problem within the Dc ($z = -0.40$, $p =.69$). On the other hand, there was a significant negative relationship between OI and probability of solving the problem within the FtFc ($z = -2.37$, $p < .05$). In other words, within the face-to-face condition, the smaller the proportion of interactions that were spent offering information, the more likely it was that they would solve the problem correctly.

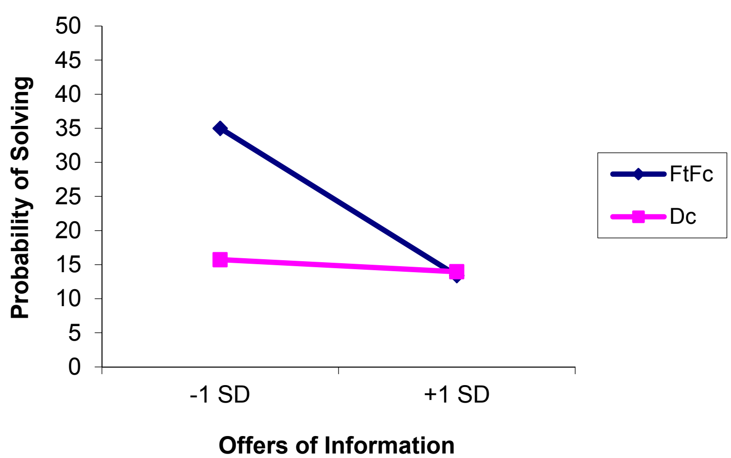

Figure 4: *Probability of solving a problem as a function of condition and offers of information.*

Assessing the condition × RI interaction (see Figure *5*), we find the same pattern of results. Again, contrary to Hypothesis 4b, there was no relationship between RI and probability of solving the problem correctly amongst the Dc ($z = -0.44$, $p = .66$). On the other hand, there was a significant relationship within the FtFc ($z = -2.54$, $p < .05$). As with the offers of information, within the face-to-face condition, the smaller the proportion of interactions that were spent asking for information, the greater the likelihood that the participant would solve the problem.

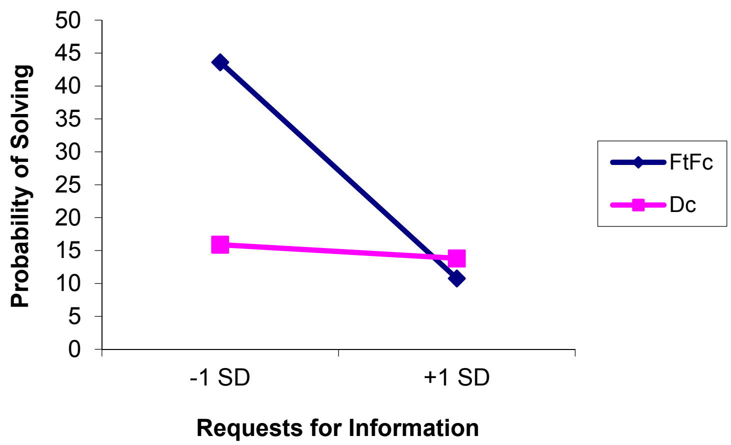

***Figure* 5:** *Probability of solving a problem as a function of condition and requests for information.*

3.3.1.2.2 Multinomial analysis

Once again, a multinomial analysis was conducted to assess the impact of requests and offers of speculation and information on either solving the problem alone or solving the problem as part of a team. Both of these were again compared to not solving the problem at all.

The first set of equations included the problem difficulty, condition, Offers of Speculation (OS) (centered), Requests for Speculation (RS) (centered), and all of the two- and three-way interactions between condition, OS, and RS. A different pattern of significance was found across the two equations. Non-significant three- and two-way interactions were removed one step at a time, as were any non-significant lower-order main effects not included in the interactions. The results of the final models are shown in Table 7.

Looking at the results shown in Table 7, we see that when predicting the probability of solving the problem alone, after controlling for the difficulty of the problem, only OS predicted solving the problem. Specifically, a 1 *SD* increase in OS *decreased* the probability of solving the problem alone by a factor of 0.71.

Table 7: *Coefficient estimates and standard errors of the estimate for multinomial model predicting probability of specific type of problem solving from condition, OS, and RS.*

Variable	Solving Alone			Solving as part of a team		
	ß	***SE***	***eß***	***ß***	***SE***	***eß***
Constant	-1.41*	0.31	0.24	-1.92*	0.41	0.15
Difficulty	-0.26*	0.10	0.77	-0.40*	0.11	0.67
Condition	--	--	--	1.24*	0.35	3.46
OS	-0.34*	0.17	0.71	0.36*	0.14	1.43
RS	--	--	--	-0.46	0.37	0.63
Condition × RS	--	--	--	$0.82^{\dagger}$	0.43	2.27

Note. $N = 571$ [(30 teams × 4 team members × 5 rounds) – (4 team members × 5 rounds) – (4 team members × 1 round) – (1 team member × 5 rounds)]; * $p < .05$; † $p < .10$.

Turning to the probability of solving the problem as part of a team versus not solving the problem, we see that after controlling for the difficulty of the problem, a 1 *SD* increase in OS increased the likelihood of solving the problem by a factor of 1.43. So, interestingly, while offering ideas about factoids or about the solution decreased the chances that one would solve a problem by oneself, offering such ideas did significantly increase the chances that a participant would be part of a team solution. To explain this inconsistency, one must understand how speculations could be used. If a participant is presenting a speculation to the rest of the group, it is likely done in order to elicit other speculations from the rest of the group. Therefore, by its nature, offering speculations with regard to the answer (or some part of it), is a communal activity which is likely to lead to a communal answer. This would, therefore, increase the chances of a communal response and decrease the likelihood of a solo response.

We also see that being part of the face-to-face condition significantly increased the probability of solving the problem as part of a team, as was seen in the analysis for Hypothesis 1. However, this main effect of condition was qualified by a marginally significant condition × RS interaction (see Figure 6). To probe this interaction we again turn to the online tool provided by Preacher et al. (2010). The slopes for RS were not significant in either the FtFc ($z = 1.59$, $p = .11$) or the Dc ($z = -1.22$, $p = .22$). Further, there was no significant difference between conditions regarding the probability of solving the problem as a team at low levels of RS ($z = 0.84$, $p = .40$). However, there was a significant difference between the FtFc and the Dc at high levels of RS ($z = 3.33$, $p < .001$). Participants who were face-to-face were much more likely to solve the problem as part of a team when they asked their fellow meta-teammates for speculations than participants who used computer mediated communication.

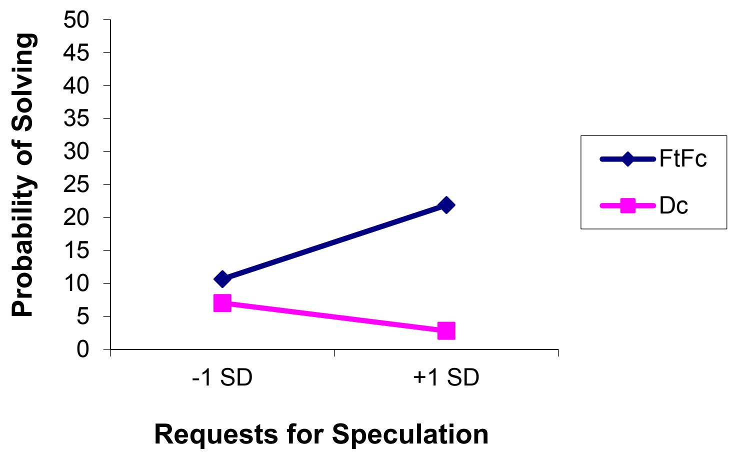

Figure 6: *Probability of solving a problem as part of a team as a function of condition and requests for speculation.*

The second set of multinomial equations included the problem difficulty, condition, OI (centered), RI (centered), and all of the two- and three-way interactions between condition, OI, and RI. Again, a different pattern of significance was found across the two equations. Non-significant three- and two-way interactions were removed one step at a time, as were any non-significant lower-order main effects not included in the interactions. The results of the final models are shown in Table 8.

Table 8: *Coefficient estimates and standard errors of the estimate for multinomial model predicting specific type of problem solving from condition, OI, and RI.*

Variable	**Solving Alone**			**Solving as part of a team**		
	ß	***SE***	***e^ß***	***ß***	***SE***	***e^ß***
Constant	-2.24*	0.16	0.11	-3.48*	0.39	0.03
Difficulty	-0.29*	0.10	0.75	-0.36*	0.11	0.69
Condition	--	--	--	1.06*	0.46	2.89
OI	-0.14	0.16	0.87	0.31	0.29	1.37
RI	-0.08	0.16	0.92	0.10	0.28	1.10
Condition × OI	--	--	--	-1.27*	0.38	0.28
Condition × RI	--	--	--	-1.48*	0.50	0.23
OI × RI	-.38*	0.17	0.68	-0.50*	0.23	0.60

Note. N = 571 [(30 teams × 4 team members × 5 rounds) – (4 team members × 5 rounds) – (4 team members × 1 round) – (1 team member × 5 rounds)]; * p < .05; † p < .10.

Examining the probability of solving the problem alone, we see that, after controlling for the difficulty of the problem, there was a significant OI × RI interaction (see Figure 7). Within this crossover interaction, the slopes for OI at high levels of RI approached significance (z = -1.86, p = .06) as did RI at low levels of OI (z = 1.82, p = .07). In other words, across conditions, being high or low in both offers of and requests for information decreased the probability of solving the problem alone, whereas being high in one and low in the other increased this probability.

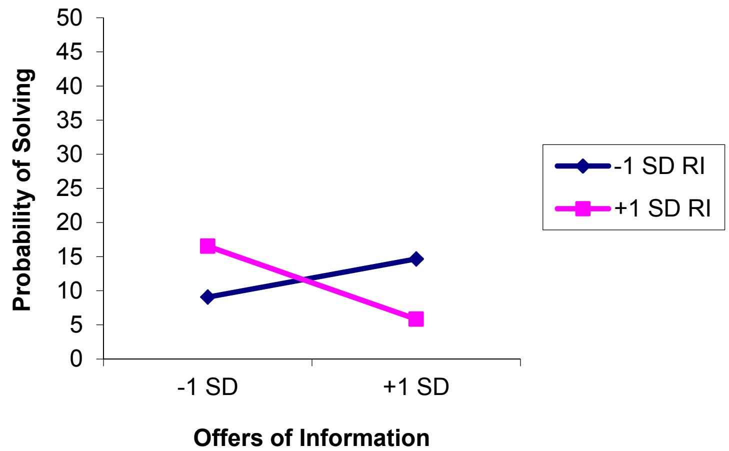

Figure 7: *Probability of solving a problem alone as a function of offers of and requests for information.*

Examining the probability of solving the problem as a team, we see from Table 8 that, after controlling for the difficulty of the problem, there was a significant main effect of condition, as we saw in previous analyses, but, again, this main effect was qualified by significant condition × OI and condition × RI interactions. Along with these two interactions, there was also a significant OI × RI interaction.

Within the condition × OI interaction (see Figure 8), there was a significant negative slope of OI within the FtFc ($z = -3.18$, $p < .01$), but not within the Dc ($z = 1.06$, $p = .29$). In other words, while the proportion of their interactions that were spent offering information within the distributed condition did not alter their probability of solving the problem as a team, within the face-to-face condition the greater the proportion of interactions that were spent offering information, the less likely it was that they would be part of a group solution.

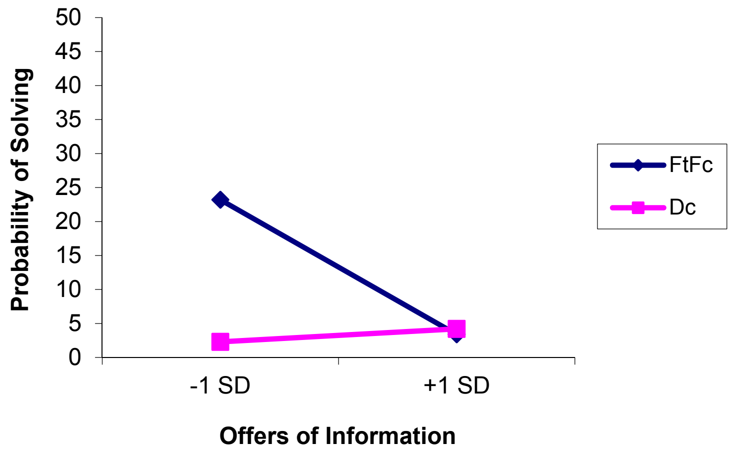

Figure 8: *Probability of solving a problem as part of a team as a function of condition and offers of information.*

Within the condition × RI interaction (see Figure 9), as with the condition × OI interaction, there was a significant negative slope of RI within the FtFc ($z = -3.14$, $p < .01$), but not within the Dc ($z = 0.34$, $p = .73$). In other words, within the distributed condition the proportion of interactions spent requesting information made no difference with regard to the probability of solving the problem as a team. In the face-to-face condition, on the other hand, spending a large proportion of one's interactions requesting information made it less likely that one would be part of a team solution.

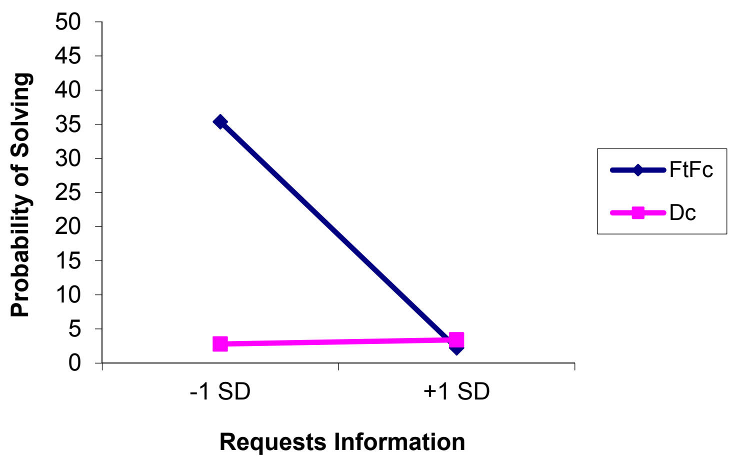

Figure 9: *Probability of solving a problem as part of a team as a function of condition and requests for information.*

Again, it is likely that both of these results (condition × OI and condition × RI) point to the idea that an excessive amount of time spent on these types of interactions likely led to a great deal of redundant information sharing within the face-to-face condition and this did not further the development of a solution within the group.

Finally, assessing the OI × RI interaction (see Figure 10), within high levels of RI, there was a marginally significant negative slope of OI ($z = -1.88$, $p = .06$) and within high levels of OI, there was a significant negative slope of RI ($z = -2.43$, $p < .05$). More specifically, we see that when participants, regardless of condition, engage in a large proportion of information sharing, if they also engage in a large proportion of requests for information, their probability of solving the problem as part of a team is greatly diminished.

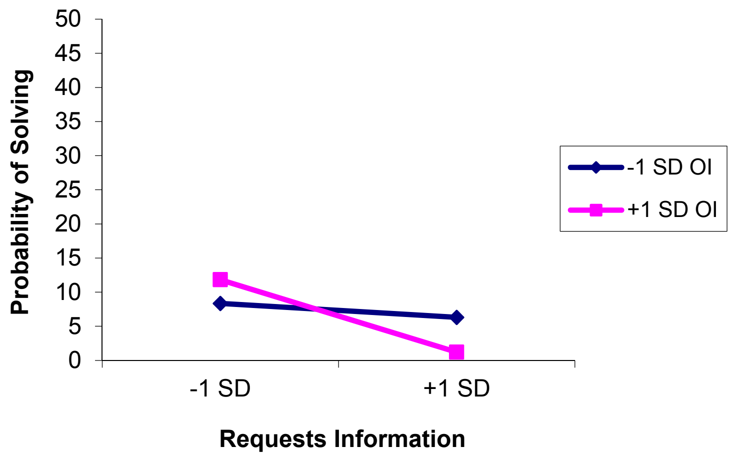

Figure 10: *Probability of solving a problem as part of a team as a function of offers of and requests for information.*

Turning back now to our original hypotheses, we see that when solving the problem alone, neither Hypothesis 4b or 4c was supported. Rather, regardless of condition, high proportions of both offers of information and requests for information actually led to a decrease in the probability of solving the problem. When assessing the probability of solving the problem as a team, contrary to Hypothesis 4c, we see that across conditions, offers of speculation were associated with a higher probability of correctly solving the problem. Hypothesis 4b was only partially supported. Amongst distributed condition participants, we did see that offers of information were positively associated with the probability of solving the problem as a team. On the other hand, there was no association between requests for information and probability of solving the problem as a team within the distributed condition. Amongst face-to-face condition participants, higher proportions of both offers of and requests for information were associated with a decreased likelihood of solving the problem as a team, which was not predicted within any of the hypotheses.

3.3.2 Hypothesis 5

Hypothesis 5 predicted that liking of one's teammates, as well as being liked by one's teammates, would be associated with better performance (i.e., more problems solved). To assess this hypothesis, we predicted the number of rounds correctly solved from condition,[10] OR (centered),[11] HR (centered) and LR (centered).[12] Furthermore, to assess whether the impact of the various liking scores were moderated by condition, the interactions of each of the liking variables with condition were included. Because the dependent variable (DV), number of problems solved, was count data and, therefore, constrained to be non-negative, a Poisson model was fit to the data using a log link function, where π_{ij} is the expected count of correctly solved problems and β_n is the log of the regression coefficient (Rasbash et al, 2009; see Equation 4).

$$\log(\pi_{ij}) = \beta_0\text{constant} + \beta_1\text{condition} + \beta_2\text{OR} + \beta_3\text{HR} + \beta_4\text{LR} + \beta_5(\text{condition} \times \text{OR}) + \beta_6(\text{condition} \times \text{HR}) + \beta_7(\text{condition} \times \text{LR}) \quad (4)$$

Neither LR nor the condition × LR interaction were significant predictors. Therefore, they were removed from the equation and the model was rerun. Table 9 lists the coefficients and standard errors (SE) for this model.

Table 9: *Coefficient estimates and standard errors of the estimate for poisson model assessing Hypothesis 4.*

Variable	β	**SE**	$z = \beta$/SE	p	e^{β}
Constant	-0.27	0.17	-1.59	*n.s.*	0.76
Condition	0.34	0.22	1.55	*n.s.*	1.41
OR	-0.14	0.19	-0.74	*n.s.*	0.87
HR	0.64	0.17	3.76	< .01	1.90
Condition × OR	0.38	0.23	1.65	< .10	1.46
Condition × HR	-0.60	0.22	-2.73	< .01	0.55

Note. $N = 120$.

The highest rating of other team members (HR) predicted the number of rounds solved. An increase of one *SD* in the highest rated other team member increased the number of problems solved by a factor of 1.90. Considering, again, that low scores on HR appeared to indicate a lack of overall positivity towards any one of a participant's meta-teammates, this discontent did not bode well for problem solving. It appeared that it was the lack of positivity towards their team members and not the presence of positivity (LR) that was driving this impact, because we see that LR did not influence problem solving at all.

The presence of a significant condition × HR interaction, as well as a marginally significant condition × OR interaction, however, qualified the HR main effect. As with the analysis for

[10] For ease of interpretation (positive rather than negative β), Dc was used as the reference category for condition.
[11] Unless otherwise stated, variables were centered around the grand mean.
[12] HR and LR were used rather than AO as these variables allowed for a clearer specification of which factor, liking or disliking other meta-teammates, was at play.

Hypothesis 4, these interactions were broken down and assessed at 1 SD above and below the means for OR and HR across conditions.

Turning first to the assessment of the condition × HR interaction (see Figure 11) we find that, within the FtFc, there was no association between HR score and number of problems solved ($z = 0.27$, $p = .79$). However, there was a significant positive relationship between HR score and number of problems solved in the Dc ($z = 3.84$, $p < .01$). Therefore, amongst the distributed condition participants, the lower the highest rating of one's meta-teammate, the fewer problems that were solved, whereas amongst the face-to-face condition participants, the presence or absence of negativity towards their meta-teammates did not predict problems solved.

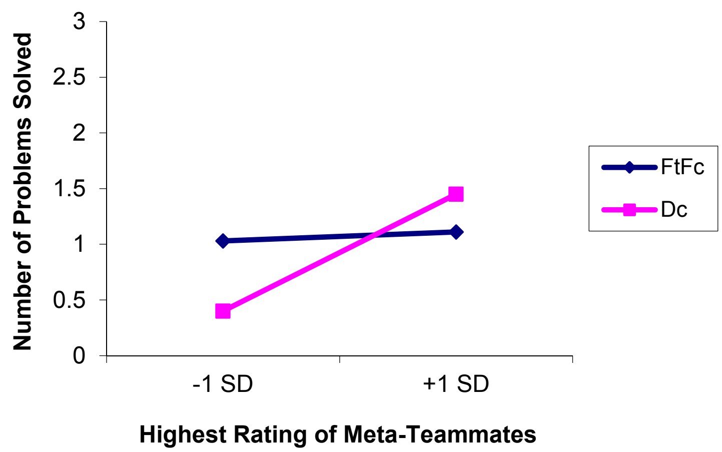

Figure 11: *Number of problems solved as a function of condition and highest rating of meta-teammates.*

Within the condition × OR interaction (see Figure 12) there was no relationship between OR and number of problems solved in the Dc ($z = -.075$, $p = .45$), whereas within the FtFc, the positive relationship between OR and number of problems solved approached significance ($z = 1.84$, $p = .06$). In other words, how one's meta-teammates rated a participant was not related to how many problems that participant solved in the distributed condition. However, in the face-to-face condition, the more well liked a participant was, the greater the number of problems they solved.

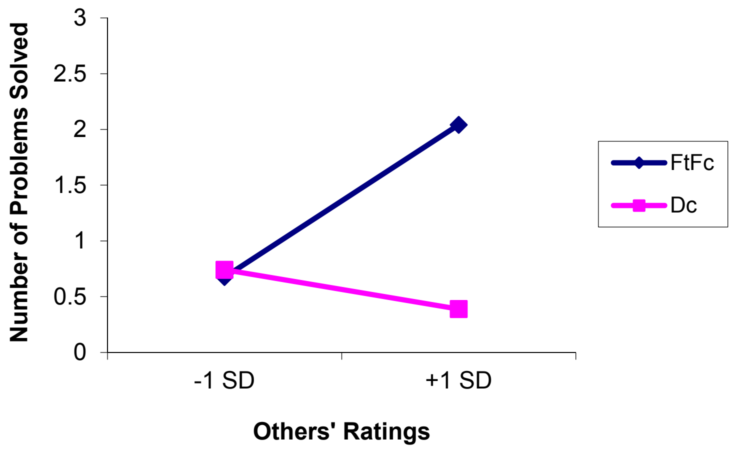

Figure 12: *Number of problems solved as a function of condition and others' ratings.*

To sum up, it appeared that within the distributed condition, how negatively a participant viewed their meta-teammates predicted the number of problems that participant would solve, with more negative perceptions leading to fewer problems solved. On the other hand, within the distributed condition, how a participant was viewed by their meta-teammates did not significantly predict their likelihood of solving a problem. Conversely, within the face-to-face condition, participants' perceptions of their meta-teammates did not predict problem solving success; however, their meta-teammates' perceptions of the participant did somewhat predict problem solving, such that more problems were solved when the participant was more well-liked, though this relationship did not reach statistical significance.

4 Discussion

The purpose of the current study was to investigate the social and behavioural precursors to successful problem solving in meta-teams. While meta-teams, or temporary teams made up of individuals originating from other teams (or home organizations), may be beneficial because they allow members to take advantage of the differing knowledge and expertise provided by other meta-team members, there are obstacles to overcome when they are used for problem solving.

One factor that was investigated in the context of this study was the effectiveness of using CMC to facilitate team communication. While there was no difference between the face-to-face and the distributed conditions in the number of problems that were solved, allowing participants to use only CMC, as occurred in the distributed condition, led to a decreased tendency to share in the problem solving. While the physically distributed and face-to-face participants were equally likely to ask for guesses from other members, to provide uninformative responses and change or withhold at least some of the information they were sharing, physically distributed participants were much less likely than face-to-face participants to strategize together or to share their guesses with one another. Physically distributed participants were, on the other hand, more likely than face-to-face participants to spend time submitting answers and to spend time asking for and offering information to other team members. This tendency for participants using strictly CMC to spend more time focused on information-laden communication rather than speculations is consistent with research conducted by Mesmer-Magnus and DeChurch (2009) and Mesmer-Magnus et al. (2011). These researchers have found that, due to the relative difficulty of communicating through CMC as compared to face-to-face communication (i.e., it is usually much quicker to vocalize a thought than to type it out) participants who rely on CMC are more likely to focus on information-laden communication whereas individuals using face-to-face communication can afford to spend some time on other types of communication, such as relationship and trust-building statements.

Another important finding within this study was with regards to liking within meta-teams. Physically distributed participants were less well liked than face-to-face participants. Furthermore, physically distributed participants liked their meta-teammates less than did the face-to-face participants. This was particularly important because MLM revealed that participants who were physically distributed and liked their meta-teammates less, solved significantly fewer problems than those who did like at least one other member of their meta-team. In the distributed condition, liking at least one other member of your meta-team meant that you had at least one ally in your efforts to solve the problem and likely at least one other person who was sharing information with you. While how much a person liked the other members of their meta-team was not important for face-to-face participants in predicting the number of problems they solved, how much they were liked by their meta-teammates approached significance in predicting problem solving. When participants in the face-to-face condition were well liked by the other members of their meta-team, they solved more problems than when they were disliked; however, this finding did not reach statistical significance and requires further investigation in future research.

Besides liking factors, we also assessed the behavioural precursors to effective problem solving. Using a combination of qualitative analysis and binomial and multinomial analysis in MLM, we found that, after controlling for the difficulty of the problem, the proportion of interactions that were cooperating/strategizing statements and uninformative responses were significant predictors of the likelihood that a particular problem would be solved, regardless of condition. However, when we looked more closely at how a particular problem was solved, we found that only uninformative responses predicted a significant decrease in the probability of solving the problem either alone or as a team. These types of interactions did nothing to bring the group or oneself closer to a solution. They did not offer any new information or spur any new thought processes, and receiving continued responses of "no" when asking a meta-teammate for a piece of information may have led meta-team members to stop asking or offering information to that person in general. Coupled with the fact that uninformative responses were negatively correlated with offers of speculation and positively correlated with requests for information, this might have led to a profile of the participant as an individual who was unwilling to share their information, but rather was only interested in obtaining information from others, perhaps leading to a decreased likelihood of others sharing with them.

Interestingly, untrue or partially true interactions approached significance as positive predictors of solving the problem alone, but not of solving the problem as a team. By offering up untrue information or partial information, a participant could appear to be cooperating with their meta-teammates and, therefore, benefit from reciprocated information, thus giving the participant more access to clues and a better chance of solving the problem on their own. The negative result with regards to the team solution is not surprising since a participant who was willing to lie to or withhold information from their meta-teammates was likely uninterested in cooperating with them enough to submit team responses.

Finally, across conditions, there was a significant offers of information × requests for information interaction when predicting overall problem solving, solving the problem alone, and solving the problem as a team. In each case, there was a negative relationship between offers of information and the probability of solving the problem at high levels of requests for information. In other words, people who spent a great deal of time both offering and requesting information, regardless of condition, were much less likely to solve the problem, either alone or as part of a team, than any other combination of offers of information and requests for information. One reason for this might have been that those who spent a majority of their time in these types of interactions were likely providing (and asking for) redundant information. This idea will be discussed more extensively below.

Another reason for the finding that offering and requesting a great deal of information led to fewer correct responses might be that participants who simultaneously offered and asked for information were ignored by their fellow teammates who took the information offered, but did not reciprocate when asked for information. Why might this have happened? To understand this we might first look at the situation where one of these types of interactions was high and the other low. For instance, when participants made many requests for information, but few offers of information, we might assume that at least some of the requests resulted in information being shared with them. If they offered little information in return, that meant they simply had more information to go on than other participants and more information meant that they were more likely to solve the problem. On the other hand, when participants offered a great deal of information, but requested little in return, the norm of reciprocity, which argues that people feel the need to give back when something has been given to them (Gouldner, 1960), may have led fellow meta-team members to offer their own information in return. The effect of that would be that if a participant sent out a piece of information to all the other team members and each member offered a piece of information in return, then that one piece that the participant sent out would lead to three times the information in return. Again, more information leads to a higher likelihood of submitting a correct response. However, when a person both offered and asked for a great deal of information, people may have been released from the norm of reciprocity. They may have interpreted the offers of information as having an ulterior motive.

Finally, the finding that offering and requesting a great deal of information led to fewer correct responses might also have been a result of the time involved with using this strategy. If a participant spent most of their time offering and asking for information, they may have had very little time to integrate the information that they received into a coherent answer. Without an analysis of the participants as receivers, it is difficult to know to what extent each of these explanations is correct.

Taking the condition into perspective, we found that, contrary to our hypothesis, after controlling for the difficulty of the problem, neither one of the two speculation variables (requests or offers of speculation) were significant predictors of problem solving overall. However, when we examined the specific type of problem solving behaviour, we found that across conditions, increases in offers of speculation led to a significant decrease in solving the problem alone. On the other hand, offers of speculation increased the probability of solving the problem as a team. This finding is not surprising in light of the fact that offering a speculation about either a clue or what the answer might be is inherently cooperative. Further, these findings are commensurate with the findings of Sheldon and McGregor (2000), who found using MLM that participants with prosocial values performed worse within their groups, but groups high in prosocial values across members outperformed groups predominated by competitive orientations. If a person had an idea about the right answer, but wanted to act alone and still appear to be cooperating, the best and easiest course of action would be to offer up information to others that they felt was not important to solving the problem, not to offer up speculations that might lead others to the right answer.

In addition to the findings with regards to offers of speculation, a tendency to spend a large proportion of one's interactions requesting speculations made it much more probable that one would solve the problem as part of a team when they were face-to-face than when they were physically distributed. This finding is likely related to the ease of communication inherent in face-to-face conversations. It would be natural in a conversation and take little time to ask someone "What do you think?" However, when this message is typed it becomes much more important and much more likely to be viewed as an attempt to steal information. It might be that when participants were face-to-face, a request for speculation was more likely to be answered than when participants were physically distributed. Unfortunately, this was beyond the scope of the current study, but might be an interesting avenue of research in the future.

When assessing the differential impact across groups of offers of information and requests for information, within the face-to-face condition there were negative relationships between both offers of information and requests for information and the probability of solving the problem either overall or when specifically solving the problem as a team. Also, participants who were face-to-face who engaged in few offers of information or requests for information were significantly more likely than their physically distributed counterparts to solve the problem, either overall or as a team. In other words, face-to-face participants who offered little information and asked for little information were the most likely to solve the problem, and specifically, they were most likely to solve the problem as a team.

At first glance, these results may seem somewhat counter-intuitive. If the problem is solved as a team, it is likely that one's fellow teammates who also solved the problem were also low in both offers of information and requests for information. If little information is getting passed around, how is the problem getting solved? An important distinction that needs to be made here is that between relatively little information (i.e., 1 SD below the mean) and no information. Within the face-to-face condition, approximately 20% of the average participant's interactions were offers of information and approximately 7% were requests for information. While 1 SD below the mean for requests for information likely meant that few if any requests were being made, 1 SD below the mean for offers of information meant that some information was still being exchanged without a great deal of repetition. Clearly enough information was being exchanged so that they could solve the problem. One problem with offering and requesting a great deal of information was that there was a limited amount of information that one could offer. Each participant only received six pieces of information. If their offers of information were high, it was likely because they were repeating the same clues over and over again. After offering a piece of information to others this piece of information, by definition, becomes a shared piece of information. According to Mesmer-Magnus et al (2011), "Groups spend more time discussing shared (commonly held) information that is already known by all group members than unshared information that is unique to individual team members" (p. 215). This was a problem especially in the face-to-face context, where the redundant information led participants down pathways that resulted in an incorrect answer. As discussed by Mesmer-Magnus et al. (2011), one drawback of face-to-face communication is that one does not have the opportunity to evaluate the information offered in the same way that one does in CMC. For example, in the following excerpt from one meta-team's interactions, the information provided by "Fire" leads them towards a false target.

> ***Fire***: And, the date, possible date is the 10th….
>
> ***Air***: 10th? …For what? Attacking where?
>
> ***Fire***: Uh, Tauland embassy in Zetaland is hosting an international conference on the 10th.
>
> ***Earth***: Okay.
>
> ***Fire***: So that may be site even…. The potential target is the Tauland embassy, this means Tauland embassy in Zetaland hosting the international conference.
>
> ***Air***: Okay…. Something big on April, in April, but there's no indication there's anything in April, so would that be out of the context because nothing has been said about April…
>
> ***Earth***: So it won't be April?
>
> ***Water***: So it's March?
>
> ***Air***: Yeah, probably it's March. Who had the March email?

The team members spent several minutes after this pursuing the idea that an attack on the Tauland embassy in Zetaland would take place on the 10th of March. In fact, other clues that they had previously read would have excluded this target, but the importance of this clue was overestimated, especially when it was repeated, and team members forgot about the previous clues. They were ultimately unsuccessful at solving this scenario. These participants were credited with many offers of information and requests for information. However, because they had one particular theory about the solution, they focused on and repeated the same unimportant clues. In this case, once you knew that the target would not be a protected site and that all the targets in Zetaland were protected, the information about the conference was irrelevant.

On the other hand, a very successful team (they solved all five scenarios), used a combination of computer-mediated communication and face-to-face communication. Below is an excerpt from their interaction:

> ***Water*** (pointing at information sheet): These three groups can attack year round. These two groups can attack Thetaland. These sections of these countries are targeted quite often. These plants are unguarded. This is a possible attack date.
>
> ***Fire***: Okay, so I'm just gonna give. I think this might be the only definitive thing that I got. It says "All the members of the Emerald group are now in custody".
>
> ***Water***: So it's not them.
>
> ***Fire***: Okay, so, I got the attack will occur right after the new control valve is installed….Does it say when it is being installed?
>
> ***Water***: August 15th.

The members of this team used CMC to share many of their clues with one another, and then discussed them in a very succinct and focused manner, asking for very little if any information. There was very little repetition of clues, and therefore, their offers of information, as well as their requests for information, were lower than average.

Ultimately, the key to solving the problems as a team was not necessarily to offer information over and over again, but rather to offer the information in a manner that gave the team a chance to evaluate it simultaneously against other clues, thus allowing for more logical speculations (or inferences) about the value of a clue. One problem that was evident when assessing the transcript was that in many instances of unsuccessful problem-solving, participants read one clue that they felt was important, and this interpretation coloured their evaluation of any clues that followed.

> ***Fire***: So, it says, Orange group has a history to attack the embassy.
>
> ***Water***: I think we're only left with the Aqua group.
>
> ***Air***: But it could be the Orange 'cause it says the Orange and Indigo groups, well I know the Indigo is out of it, so, the Orange group wants to attack the interests of Alphaland, Betaland, and Gammaland. So, anyone have anything on, information on the Orange group?
>
> ***Earth***: Orange group members have entered Alphaland and Betaland.
>
> ***Air***: So it might be Orange.

Earth: Yeah, it might be Orange.

6 minutes later, they receive the solution indicating that Aqua was the correct group.

Water: Yeah, I had a feeling it was the Aqua group, but then we changed it to Orange.

In this case, the clue about Orange's history biased the team to evaluate all clues indicating confirming evidence with regards to the fact that it must be the Orange team even though, at one point, they in fact did believe it was the Aqua group.

In summary, 30 meta-teams of 4 participants each (15 face-to-face, 15 distributed) attempted to solve five logic problems using the Planning Task for Teams (PLATT) program. Each meta-team member was given only partial information and, in order to solve the problem, was required to elicit information from their teammates. Using a combination of qualitative analysis and binomial and multinomial multilevel modeling, the attitudinal and behavioural data were assessed. The results indicated that distributed and face-to-face meta-teams were equally effective when it came to solving the problems, but that the nature of the problem solving was dependent on the nature of the team (supporting Hypothesis 1). Face-to-face teams were much more collaborative in their work and were also much more likely to have positive views of each other than distributed participants (supporting Hypotheses 2 & 3). As predicted in Hypothesis 4a, providing uninformative responses (such as "I don't know") decreased the likelihood of solving a problem, but cooperating/strategizing increased the likelihood of a successful interaction. Hypotheses 4b and 4c were not supported. Rather, the findings indicated that face-to-face team members who over-shared their information and asked many questions reduced the likelihood that they would be successful in their attempts at problem solving. Finally, Hypothesis 5 was partially supported in that participants in the face-to-face condition, but not in the distributed condition, who were more well-liked were also more likely to be successful in problem solving. On the other hand, within the distributed condition, but not the face-to-face condition, liking one's meta-teammates less decreased the likelihood of problem solving. Overall, the findings of this study shed light on important considerations when understanding the use of meta-teams and how their effectiveness may differ when considering distributed versus face-to-face teams.

4.1 Future considerations

While the current study shed light on some of the important behavioural precursors to problem solving across different team distributions, there were important questions that remained unanswered about the nature of the interactions and the meta-team dynamic.

In the current study, it was assumed that leading participants to believe that they were similar to other members of their higher-order group (Earth, Air, Fire, or Water) would create the circumstances necessary for a minimal group. Tajfel, Billig, Bundy, and Flament (1971), in their foundational work on the minimal group paradigm, have shown that merely creating some commonality amongst individuals creates a bias favouring one's in-group, even when that commonality is trivial or invented. Tajfel and his colleagues found that splitting participants up based on their preference for the paintings of one artist rather than another caused them to later allot more imaginary money to members of their in-group than members of their out-group. In the current study, it was anticipated that creating a commonality based on alleged personality would create the same bias for participants and other members of their higher-order group. However, because no measure of closeness to either the higher-order group or the meta-team was taken, there is no way to confirm whether or not this attempt to create a minimal higher-order group was successful. A future study that includes this measure might assess not only whether the attempt to create a minimal higher-order group was successful, but also whether participants identified with the meta-team versus the higher-order group differently across conditions.

Another consideration not investigated in the current study was the uniqueness of the information shared amongst meta-team members. In the current study, categories were created to separate the offers/requests for information from the offers/requests for speculation. However, no distinctions were made with regards to whether the information/speculations were unique or were repeated.

While it was important in the context of this study to create a clear distinction between face-to-face and distributed participants, the reality is that even amongst distributed meta-teams, the likelihood that interactions would take place solely over electronic means is slim. Rather, a more realistic arrangement would include some way for distributed teams to communicate outside of the PLATT program. This might be achieved either through the use of a "teleconference" or through "video teleconferencing." Mesmer-Magnus et al. (2011) argue that teams that combine CMC with more face-to-face interactions receive the best of both worlds. They can take advantage of the relationship building, coordination, and so on inherent in face-to-face communication, as well as the opportunities for equal participation and thoughtful reflection inherent in CMC. A future study that includes this hybrid group could provide a clearer picture of the problem solving strategies of more realistic meta-teams. In addition, future work might examine the impact of differences in organizational culture on collaboration in a meta-team, as well as the role of trust.

The current study focused solely on the interactions initiated by participants, but did not investigate the responses to these interactions. A future study that investigated who was the target of various types of interactions simultaneously with what types of interactions were engaged in by that target would help shed light on some of the unanswered questions of the current study. For instance, what type of interaction—requests or offers—elicited more information from fellow meta-team members? Was it the case that people provided information when they were asked for it, or were requesters viewed as takers? Were offers viewed as a sign of trust and thus more effective at eliciting information from others, or were those who openly offered or shared information taken advantage of and not offered anything in return for their generosity?

Another factor that was not investigated in this study was the impact of level of interaction. In other words, what impact might the talkativeness of a group, as an indicator of interaction, have on performance? One might argue that the more interactive (i.e., talkative) a group is, the more successful they should be. Looking at it from the flipside, teams who did not communicate at all were unlikely to be successful. However, too much interaction (in the form of repetitive or bias-confirming information sharing) also became a problem, not unlike the phenomenon of groupthink. According to Levi (2007), "the team's desire to reach agreement on an issue becomes more important than its motivation to find a good solution" (p. 82). While this was not actually investigated in the current study, some casual observations of the interactions, especially amongst the face-to-face teams as discussed above, did indicate that participants were easily swayed towards one answer and that much of the interactions were then geared towards finding confirmatory information, while few people were apt to negate suggestions made by other team members. Thus, while these teams were quite talkative, the discussion was not useful. For example, 5 minutes into a round, one team had the following discussion:

> ***Fire***: …it has to be this (points to the paper).
>
> ***Water***: Indigo?
>
> ***Fire***: Indigo.
>
> ***Water***: Indigo, okay, I agree.
>
> ***Air***: Okay, so can we be sure about Indigo?
>
> ***Water***: Yeah, Indigo, yeah, that's very sufficient. (pause) Okay, now just let's focus on Indigo.
>
> ***Air***: Okay, fine, no problem.

In fact, Indigo could be eliminated with one clue, but the tendency for team members to agree with each other when they were cooperating often led them down dead ends, thus wasting valuable time. This team spent the next 3 minutes trying to find information that would confirm their suspicion that it was Indigo, only to discover that Indigo was the one team with whom the mercenary (who, they were informed, was always involved in the terrorist plot if he/she was mentioned) would not work (see Annex D.2.2).

Unlike the previous discussion surrounding the Orange group, it was not the influence of a particular clue that shaped the direction of the team's focus, but rather, it was a suggestion made by one of the meta-team members. The rest of the team, rather than attempting to find disconfirming information, which could easily have been found, attempted to find other clues to confirm that the solution did fit the hypothesis. An analysis of these types of cooperative yet counterproductive tendencies was beyond the scope of this paper, but would be important to investigate in future research.

Further, as mentioned earlier, follow-up studies that investigate the role of trust within meta-teams as well as varying levels of virtuality in meta-teams would contribute to a better understanding of the most successful strategies for meta-team collaboration. Likewise, an analysis of the implications of receiving information versus supplying information would enhance understanding of the consequences of particular types of interactions within the meta-team environment and how these might influence attitudes of meta-teammates as well as successful, or unsuccessful, performance, within the meta-team environment. Future research that provides participants with a more varied and realistic means of communicating in distributed teams would also allow for a greater understanding of problem solving behaviours in distributed meta-teams. Finally, an analysis of the personality, video and transcript data collected for this study could also provide fruitful avenues of future research on meta-team interaction.

4.2 In summary

To summarize, we found that there was no difference between meta-teams who were face-to-face and those who were physically distributed regarding the number of problems that they solved correctly. There was a difference, however, in how the problems were solved. Face-to-face participants were much more likely than physically distributed participants to solve the problem as a team rather than alone. Further, face-to-face participants also liked their teammates more and were more liked by their teammates than distributed participants. Face-to-face participants also made more collaborative statements than their distributed counterparts and these collaborative statements were strongly associated with correct responses.

Amongst face-to-face participants, who could communicate either via the computer or verbally, an over-abundance of both offers of information and requests for information led to a very low probability of solving the problem, especially when solving the problem alone. On the other hand, lower levels of at least one of these categories of interaction led to a higher probability of problem solving as a team. Teams that required a great many questions and repeated the same clues over and over again (resulting in a large proportion of offers of information) likely were disorganized and struggling to determine what the correct answer was or how they might go about narrowing down the information to get the answer. On the other hand, face-to-face teams that were well organized and had good ideas about how to go about the task needed relatively few offers of information (they did not require the clues to be repeated over and over again) and asked focused questions, often leading to positive results (a correct answer).

For distributed participants, either offering others information (and likely receiving information in return) or requesting information (and being answered) led to a higher probability of solving the problem. However, both offering and asking for a lot of information or very little information led to a lower probability of solving the problem. Those distributed participants who did not ask and did not offer information likely received little information in return, especially during the later sessions where they were likely viewed as unhelpful by their teammates. Those who offered and asked for a great deal of information likely appeared to be untrustworthy, thus receiving little information in return.

What these results indicate is that, in order to be successful within a meta-team environment, one must take into account the level and nature of communication available to the meta-team and how one's interactions are coming across to others. Appearing disorganized by asking a lot of questions and offering a great deal of (likely irrelevant) information makes it highly unlikely that one would be successful, regardless of the communication environment. It appears to be best to choose a strategy (offer or ask) and stick with it. In both face-to-face and distributed environments, those appear to be the most successful strategies. Finally, having the opportunity to communicate face-to-face did offer a large advantage over being distributed, if the goal was offering up a joint solution, as is the case in most meta-team environments.

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Annex A Pre-experimental information package

Study Name: Meta-team problem solving

Short Description: Participants will work in teams of four to uncover information about a potential terrorist attack in a Clue-type situation where "who", "what", "when", and "where" information must be deciphered.

Long Description: Participants will complete a series of demographic and personality questionnaires. Following that, participants will be assigned to represent one of four groups (Earth, Air, Fire, or Water) and will work with members of the three other groups in order to identify a potential terrorist attack. Using the Planning Task for Teams (PLATT) program, participants will receive incomplete information about who (which terrorist group), where (which country is being attacked), what (what the target is within the country), and when (what is the date of the planned attack). While each individual's information is incomplete to identify the threat, the team as a whole will have all the necessary information. The participant's goals are to gather the information, sift through to identify the key pieces, and be the first person in the meta-team (made up of members of four separate groups) to correctly identify all four pieces of information in order to gain points for your group. The group (Earth, Air, Fire, or Water) that has the most points at the conclusion of the study will receive a bonus prize of $500 to be split among the winning group members.

Participation in this experiment involves minimal risk (e.g., minor eye strain). However, participating in this study may enable you to gain insight into your own problem solving and collaborative behaviours, which may benefit you. This research will also benefit the Canadian Forces in their acquisition of knowledge leading to improvements in meta-team collaboration in distributed and co-located groups.

Your participation in the study is completely voluntary. You may ask questions of the researcher(s) at any time, and you may end your participation at any time.

Participation is confidential in that your name will not be linked to the data. The sessions will be videotaped for transcription purposes, however, your name will not be used at any point during the study. The experimental data will be treated as confidential ('Protected B' IAW CD Security Requirements), and not revealed to anyone other than the DRDC Toronto and York University Investigator(s) without your consent except as data unidentified as to source.

Eligibility Requirements: It is important that participants in the meta-teams are not acquainted prior to participating in the study, so please do not sign up with friends for the same sessions.

Duration: The study will take approximately 2 hours to complete.

Credits/Pay: For taking part in this study, participants will receive $30.20. Participants who are part of the winning group will also receive a bonus prize of $500 to be split among the winning group members.

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Annex B Voluntary consent form

VOLUNTARY CONSENT FORM FOR HUMAN SUBJECT PARTICIPATION

Protocol: L-704
Title: Understanding Competitive and Co-operative Problem Solving Behaviour in Meta-Team Situations
Principal Investigator: Dr. Emily-Ana Filardo, DRDC Toronto
Co-Investigators: Mr. Michael Prentice, York University; Dr. Angela Febbraro, DRDC Toronto; Dr. Ann-Renee Blais, DRDC Toronto
Thrust: 10af07

I, _______________________ (name) of _______________________________________ (address and phone number) hereby volunteer to participate as a subject in the study "**Understanding Competitive and Co-operative Behaviour in Mixed-Group Situations**" (L-704). I have read the information package on the research protocol, and have had the opportunity to ask questions of the Investigator(s). All of my questions concerning this study have been fully answered to my satisfaction. However, I may obtain additional information about the research project and have any questions about this study answered by contacting Dr. Emily-Ana Filardo (416-635-2000, ext. 2308), or Mr. Michael Prentice (416-736-2100, ext. 40219).

In this experiment I will be asked to complete a series of self-report measures of personal attitudes and beliefs. I will then participate in a competitive problem-solving game with three other individuals. All tasks will be completed on the computer. I may be video-taped during the group work task. Portions of the video may be used for presentation purposes, however, all identifying data will be removed prior to such screenings. I may refuse to have my video-taped session used for screening purposes if I so choose.

I have been assured that participation in this experiment involves minimal risk (e.g., minor eye strain). Also, I acknowledge that my participation in this study, or indeed any research, may involve risks that are currently unforeseen by DRDC Toronto.

I understand that participating in this study may enable me to gain insight into my own problem solving and collaborative behaviours, which may benefit me. I also understand that this research will benefit the Canadian Forces in their acquisition of knowledge leading to improvements in meta-team collaboration in distributed and co-located groups.

I have been told that I will be asked to participate in 1 session of approximately 2 hours in duration.

I hereby consent to undertake to provide responses to questions that are to the best of my knowledge, truthful and complete. I understand that confidentiality will be provided to fullest extent possible by law. I have been advised that the information I reveal and the experimental data concerning me will be treated as confidential ('Protected B' IAW CD Security Requirements), stored in secure files, and not revealed to anyone other than the DRDC Toronto and York University Investigator(s) without my consent except as data unidentified as to source. Moreover, should it be required, I agree to allow the experimental data to be reviewed by an internal or external audit committee with the understanding that any summary information resulting from such a review will not identify me personally. All data will be kept for a period of 7 years at which time, the data will be erased from all files.

I understand that I am free to refuse to participate or respond to questions and may withdraw my consent at any time. If I refuse to volunteer, withdraw from the study, or refuse to answer any questions, this decision will not influence the relationship with the researchers or any other group associated with this project. Should I withdraw my consent, my participating as a subject will cease immediately, unless the Investigator(s) determine that such action would be dangerous or impossible (in which case my participating will cease as soon as it is safe to do so). I also understand that the Investigator(s) or their designate responsible for the research project may terminate my participation at any time, regardless of my wishes.

I have been informed that I will be fully debriefed regarding the aims and hypotheses of this experiment upon completion of the task.

I am aware that participation in this study entitles me to remuneration in the form of a stress allowance in the amount of $30.20 ($22.36 for CF members and public servants on duty) for completion of the entire experiment. I understand that stress remuneration is taxable. T4A slips are issued for amounts in excess of $500.00 paid during the year.

I have informed the Principal Investigator that I am currently a subject in the following other DRDC Toronto research project(s):

____ (cite Protocol Number(s) and associated Principal Investigator(s)), and that I am participating as a subject in the following research project(s) at institutions other than DRDC Toronto:

____ (cite name(s) of institution(s)).

I understand that by signing this consent form I have not waived any legal rights I may have as a result of any harm to me occasioned by my participation in this research project beyond all risks I have assumed.

Secondary Use of Data: I consent/do not consent (delete as appropriate) to the use of this study's experimental data involving me in unidentified form in future related studies provided that review and approval have been given by DRDC HREC.

Volunteer's Name: ____
Signature: ______________________________________ Date: ____________________

Name of Witness to Signature: ____
Signature: ______________________________________ Date: ____________________

Principal Investigator: ____
Signature: ______________________________________ Date: ____________________

FOR SUBJECT ENQUIRY IF REQUIRED:

Should I have any questions or concerns regarding this project before, during or after participation, I understand that I am encouraged to contact Defence R&D Canada - Toronto (DRDC Toronto), P.O. Box 2000, 1133 Sheppard Avenue West, Toronto, Ontario M3M 3B9. This contact can be made by surface mail at this address or in person, by phone or e-mail, to any of the DRDC Toronto numbers and addresses listed below:

Principal Investigator or Principal DRDC Toronto Investigator:

Dr. Emily-Ana Filardo (416-635-2000, ext. 2308, Emily-Ana.Filardo@drdc-rddc.gc.ca)

Chair, DRDC Human Research Ethics Committee (HREC):

Dr. Jack Landolt (416-635-2000, ext. 2120, Jack.Landolt@drdc.rddc.gc.ca)

This study has also received approval from York University's Ethic Committee. If you have any questions about this process, or about your rights as a participant in the study, please contact:

Sr. Manager & Policy Advisor for the Office of Research Ethics, 309 York Lanes, York University (telephone 416-736-5914 or e-mail ore@yorku.ca).

I understand that I will be given a copy of this consent form so that I may contact any of the above-mentioned individuals at some time in the future should that be required.

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Annex C Demographics questionnaire

Age: _______

Gender: M F

Major: ________________________________

Current Year of Study: 1st year 2nd year 3rd year 4th year Higher

Ethnic Background:

□ White
□ Chinese
□ South Asian (e.g., East Indian, Pakistani, Sri Lankan, etc)
□ Black
□ Filipino
□ Latin American
□ Southeast Asian (e.g., Cambodian, Indonesian, Vietnamese, etc)
□ Arab
□ West Asian (e.g., Afghan, Iranian, etc)
□ Japanese
□ Korean
□ Aboriginal
□ Other – please specify __________________________________

First language:

□ English
□ French
□ Other (please specify) _____________

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Annex D Organizing sheets and lists of factoids

D.1 Scenario 1

D.1.1 Organizing sheet for Scenario 1

Possible Groups Involved

Azure Brown Violet Purple

	Potential Targets within Countries (cross out boxes to eliminate targets)						
Target Country	Tauland Embassy in	Zetaland Embassy in	Chiland Embassy in	Psiland Embassy in	Iotaland Embassy in	Visiting Dignitary in	Financial Institution in
Tauland							
Zetaland							
Chiland							
Psiland							
Iotaland							

Potential Dates

March April 5th 10th

Answer:

The ____________________ group plans to attack the ______________________________

in _____________________ on ________________________ .

e.g., The ***Beige*** group plans to attack the ***church*** in ***Omegaland*** on ***July 31st***.

D.1.2 List of factoids for Scenario 1

Email subject	Email content
Venus' associations[KF]	Venus is known to work only with the Azure, Brown, or Violet groups, and won't work with locals.
Recruitment of locals[NF]	Locals in Tauland, Zetaland, and Iotaland are being recruited.
Violet and Purple capacity[NF]	Only the Violet and Purple groups have the capacity to hit protected targets.
Possible date[KF]	Venus is planning something in April on the anniversary of her father's death.
Venus' involvement[KF]	Venus, who is involved, doesn't operate in Chiland, and prefers an unprotected target to ensure the likelihood of success.
Possible date[NF]	The Purple and Brown groups want to attack the interests of Tauland, Zetaland, or Chiland in March.
Azure group history[NF]	The Azure group has a history of attacking embassies.
Protected targets[KF]	Security forces are providing highly visible, around the clock protection to all dignitaries in the region.
Protected targets[KF]	All high value targets belonging to Iotaland, Tauland, and Zetaland are well protected.
Possible date[NF]	The Tauland embassy in Zetaland is hosting an international conference on the 10th.
Violet group info[NF]	There is no new information about the Violet group operations in Chiland.
Protected targets[KF]	Countries Chiland, Psiland, & Iotaland are taking steps to protect their embassies abroad.
Brown group movement[NF]	The Brown group members have entered Tauland & Zetaland.
Purple group capacity[NF]	The Purple group is capable of attacking year round.
Possible date[KF]	The Violet group is planning something big on the 5th.
Recruitment of locals[KF]	The Brown group is recruiting locals - intentions unknown.
Surveillance of targets[NF,SF]	Reports from Tauland, Chiland, & Psiland indicate surveillance ongoing at coalition embassies.
Azure group member current info[KF,SF]	All of the members of the Azure group are now in custody.

Note: KF = Key Factoid, NF = Noise Factoid, SF = Shared Factoid; Factoids sharing a colour were grouped together. For sessions 1-16, the order of factoid distribution was Air, Earth, Fire, and Water. For sessions 17-30, the order of factoid distribution was Fire, Water, Air, and Earth. The switch was done to ensure that there were no factors specific to the factoid set received by a particular group that might influence solving the problem.

D.2 Scenario 2

D.2.1 Organizing sheet for Scenario 2

Possible Groups Involved

Tan Aqua Orange Indigo

	Potential Target within Country (cross out boxes to eliminate targets)					
Target Country	Alphaland Embassy in	Betaland Embassy in	Gammaland Embassy in	Deltaland Embassy in	Epsilonland Embassy in	Dignitary in
Alphaland						
Betaland						
Gammaland						
Deltaland						
Epsilonland						

Potential Dates

July September 19th 27th

Answer:

The ____________________ group plans to attack the ______________________________

in _____________________ on ________________________ .

e.g., The ***Beige*** group plans to attack the ***church*** in ***Omegaland*** on ***July 31st***.

D.2.2 List of factoids for Scenario 2

Email subject	Email content
Tan group member current info[KF]	All of the members of the Tan group are now in custody.
Indigo and Tan group movements[NF]	Indigo and Tan group operatives have entered Deltaland.
Orange and Indigo targets of interest[NF]	The Orange and Indigo groups want to attack the interests of Alphaland, Betaland, or Gammaland.
Protected targets[KF]	Security forces are providing highly visible, around the clock protection to all visiting dignitaries.
Protected targets[KF]	All high value targets belonging to Alphaland and Betaland are well protected as are all high value targets in Betaland.
Possible target and date[NF]	A new train station is being built in the capital of Alphaland and is scheduled to open in July.
Orange group movements[NF]	Orange group members have entered Alphaland and Betaland.
Possible date[KF]	Jupiter is planning something in September and will not risk working with locals.
Protected targets[KF]	Gammaland and Epsilonland are taking steps to protect their embassies abroad.
Indigo group movements[NF]	No traces of members from the Indigo group have been found in Deltaland or Epsilonland.
Orange group history[NF]	The Orange group has a history of attacking embassies.
Possible date[KF]	The Aqua group is planning something big on the 27th.
Jupiter's associations[KF]	Jupiter is known to work only with the Aqua, Orange, or Tan groups.
Indigo and Tan group capacity[NF]	Only the Indigo and Tan groups have a capacity to hit protected targets.
Indigo ties[NF]	The Indigo group has close ties with the local media.
Recruitment of locals[KF]	The Orange group is recruiting locals - intentions unknown.
Jupiter's involvement[KF,SF]	Jupiter, who is involved, doesn't operate in Gammaland, Deltaland, or Epsilonland, and prefers an unprotected target to ensure the likelihood of success.
Jupiter personal information[NF,SF]	Jupiter was born in Epsilonland on the 19th.

Note: KF = Key Factoid, NF = Noise Factoid, SF = Shared Factoid; Factoids sharing a colour were grouped together. For sessions 1-16, the order of factoid distribution was Air, Earth, Fire, and Water. For sessions 17-30, the order of factoid distribution was Fire, Water, Air, and Earth. The switch was done to ensure that there were no factors specific to the factoid set received by a particular group that might influence solving the problem.

D.3 Scenario 3

D.3.1 Organizing sheet for Scenario 3

Possible Groups Involved

Yellow Emerald Magenta Fuchsia

	Potential Targets within Countries (cross out boxes to eliminate targets)		
Target Country	Oil Pipeline Terminal in	Train Station in	Electric Plant in
Upsilonland			
Thetaland			
Omegaland			
Kappaland			
Lambdaland			

Potential Dates

May August 15th 24th

Answer:

The ____________________ group plans to attack the ______________________________

in _____________________ on ________________________ .

e.g., The ***Beige*** group plans to attack the ***church*** in ***Omegaland*** on ***July 31st***.

D.3.2 List of factoids for Scenario 3

Email subject	Email content
Recruitment of locals[NF]	Locals in Upsilonland and Lambdaland are being recruited.
Possible date[NF]	The Yellow group may be planning an attack in May.
Mars' involvement[KF]	Mars, who is involved, only attacks heavily protected targets and is not interested in train or bus stations as targets.
Sea attack capabilities[KF]	Only the Yellow, Emerald, and Magenta groups have the ability to attack at sea.
Possible date[NF]	The grand opening of the new train station in the capital of Omegaland is scheduled for the 24th and will be heavily protected.
Fuchsia ties[NF]	The Fuchsia group has close ties with local media.
Mars' associations[KF]	Mars does not work in Upsilonland or with the Yellow group.
Pipeline terminal info[KF]	Kappaland and Lambdaland have gas pipeline terminals but not oil pipeline terminals, and Omegaland has neither oil nor gas pipeline terminals.
Fuchsia group movement[NF]	No traces of members from the Fuchsia group have been found in Kappaland or Omegaland.
Emerald group info[NF]	There is no new information about the Emerald group operations in Omegaland.
Emerald group current info[KF]	All of the members of the Emerald group are now in custody.
Attack timing[KF]	The attack will occur right after the new control valve is installed.
Emerald, Fuchsia, and Magenta group capacities[NF]	The Emerald, Fuchsia, and Magenta groups are capable of attacking year round.
Train station info[NF]	Train stations in Upsilonland, Thetaland, and Lambdaland were recently attacked and evidence of more attacks has been found.
Electrical plant info[KF]	Electrical plants in all countries are lightly guarded.
Possible date[KF]	The new control valve is being installed at the Southern Oil pipeline terminal on August 15th.
Southern Oil pipeline info[KF,SF]	The heavily protected Southern Oil pipeline terminal is ocean-based.
Magenta and Fuchsia group movement[NF,SF]	Magenta and Fuchsia group operatives have entered Thetaland.

Note: KF = Key Factoid, NF = Noise Factoid, SF = Shared Factoid; Factoids sharing a colour were grouped together. For sessions 1-16, the order of factoid distribution was Air, Earth, Fire, and Water. For sessions 17-30, the order of factoid distribution was Fire, Water, Air, and Earth. The switch was done to ensure that there were no factors specific to the factoid set received by a particular group that might influence solving the problem.

D.4 Scenario 4

D.4.1 Organizing sheet for Scenario 4

Possible Groups Involved

Silver Teal Ash Sapphire

	Potential Targets within Countries (cross out boxes to eliminate targets)		
Target Country	Secular School in	Religious School in	Army Base in
Muland			
Xiland			
Omnicronland			
Piland			
Sigmaland			

Potential Dates

January February 1st 17th

Answer:

The ____________________ group plans to attack the ______________________________

in _____________________ on ________________________ .

e.g., The ***Beige*** group plans to attack the ***church*** in ***Omegaland*** on ***July 31st***.

D.4.2 List of factoids for Scenario 4

Email subject	Email content
Army base security[NF]	Army bases in Sigmaland now have multiple checkpoints.
Possible date[KF]	An attack is being planned for the first of the month.
Attack site info[KF]	There will be a suicide bomber attack at a school.
Use of locals[NF]	The Teal group uses only its own operatives, never employing locals.
Use of Suicide bombers[KF]	The Ash and Teal groups do not employ suicide bombers.
Recruitment of locals[NF]	The Ash group is recruiting locals - intentions unknown.
Possible date[NF]	A new army base is being built in Piland and will be completed on February 17th.
Possible date[KF]	An attack is being planned for the first month of the year.
Sapphire group info[KF]	The Sapphire group is comprised of former teachers and does not target schools.
Missing nuclear fuel[NF]	There are reports that spent nuclear fuel is missing in Muland.
Sapphire group movement[NF]	No traces of members from the Sapphire group have been found in Sigmaland.
School closures[KF]	Xiland and Sigmaland have closed all their schools.
Attack site info[KF]	No attacks are being planned on religious organizations in Muland and Omnicronland.
Religious school info[NF]	The religious schools in Piland are fanatical.
Army base protection[NF]	Omnicronland is in the process of deploying more troops to protect its military bases.
School info[KF]	Muland and Xiland have only religious schools.
Silver ties[NF,SF]	The Silver group has close ties with the media.
Silver area of influence[KF,SF]	The Silver group does not work in Piland.

Note: KF = Key Factoid, NF = Noise Factoid, SF = Shared Factoid; Factoids sharing a colour were grouped together. For sessions 1-16, the order of factoid distribution was Air, Earth, Fire, and Water. For sessions 17-30, the order of factoid distribution was Fire, Water, Air, and Earth. The switch was done to ensure that there were no factors specific to the factoid set received by a particular group that might influence solving the problem.

D.5 Scenario 5

D.5.1 Organizing sheet for Scenario 5

Possible Groups Involved

Crimson Coral Gold Turquoise

	Potential Targets within Countries (cross out boxes to eliminate targets)		
Target Country	Market Place in	Church in	Sports Venue in
Etaland			
Nuland			
Rholand			
Philand			
Omegaland			

Potential Dates

October December 8th 13th

Answer:

The ____________________ group plans to attack the ______________________________

in _____________________ on ________________________ .

e.g., The ***Beige*** group plans to attack the ***church*** in ***Omegaland*** on ***July 31st***.

D.5.2 List of factoids for Scenario 5

Email subject	Email content
Sporting event info[KF]	There are no sporting events scheduled in Omegaland or Rholand in the near future.
Crimson group movement[NF]	Members of the Crimson group have recently visited Nuland and Rholand.
Market place info[KF]	Markets in Etaland and Omegaland have been closed.
Possible date[NF]	There is a soccer championship scheduled in Etaland on the 8^{th}.
Protection of targets[NF]	All high value targets in Philand are protected.
Church info[NF]	A new church is being built in Omegaland.
Possible date[KF]	Saturn, who is involved, is superstitious and only plans to attack on the 13th of the month.
Turquoise info[KF]	No traces of members of the Turquoise group have been found in Philand.
Possible date[KF]	The Turquoise group is planning an attack in October.
Target info[NF]	The attackers are focusing on high visibility targets.
Saturn associations[KF]	Saturn does not work with Crimson or Gold groups.
Gold group visibility[NF]	There has been a lot of chatter about the Gold group.
Saturn sphere of influence[KF]	Saturn does not work in Nuland or Etaland.
Possible date[NF]	The Coral group only plans attacks in December.
Turquoise targets[KF]	The Turquoise group does not attack churches.
Use of suicide bombers[NF]	The Crimson group does not use suicide bombers.
Coral group targets[KF,SF]	The Coral group only targets military sites.
Group associations[NF,SF]	The Coral and Gold groups often work together.

Note: KF = Key Factoid, NF = Noise Factoid, SF = Shared Factoid; Factoids sharing a colour were grouped together. For sessions 1-16, the order of factoid distribution was Air, Earth, Fire, and Water. For sessions 17-30, the order of factoid distribution was Fire, Water, Air, and Earth. The switch was done to ensure that there were no factors specific to the factoid set received by a particular group that might influence solving the problem.

Annex E Post-interaction questionnaire

Based on your interaction with the other members in your team, please answer the following questions for each of the participants. First indicate your group then rate each of the other team members under their group name. These responses will NOT be shared with the other team members, so please be as honest as possible.

To which group did you belong?

Earth	Air	Fire	Water

How honest was Air/Earth/Fire/Water?

Extremely Dishonest	Very Dishonest	Somewhat Dishonest	Neither Honest nor Dishonest	Somewhat Honest	Very Honest	Extremely Honest
1	2	3	4	5	6	7

How much did you like Air/Earth/Fire/Water?

Extremely Disliked	Disliked Very Much	Somewhat Disliked	Neither Liked nor Disliked	Somewhat Liked	Liked Very Much	Extremely Liked
1	2	3	4	5	6	7

How helpful was Air/Earth/Fire/Water?

Extremely Unhelpful	Very Unhelpful	Somewhat Unhelpful	Neither Helpful nor Unhelpful	Somewhat Helpful	Very Helpful	Extremely Helpful
1	2	3	4	5	6	7

How willing was Air/Earth/Fire/Water to co-operate with the other team members?

Extremely Unwilling	Very Unwilling	Somewhat Unwilling	Neither Willing nor Unwilling	Somewhat Willing	Very Willing	Extremely Willing
1	2	3	4	5	6	7

How willing would you be to work with Air/Earth/Fire/Water again?

Extremely Unwilling	Very Unwilling	Somewhat Unwilling	Neither Willing nor Unwilling	Somewhat Willing	Very Willing	Extremely Willing
1	2	3	4	5	6	7

Have you ever met Air/Earth/Fire/Water before today? Yes No Don't Know

If you answered "Yes" to the previous question, how well did you know Air/Earth/Fire/Water?

Close friend	Friend	Acquaintance	By sight only	Did not say "yes"
1	2	3	4	5

Annex F Coding scheme

F.1 Answers submitted

Any guess at the solution sent to Headquarters, regardless of whether the guess was correct or not.

- ***Air***: The Ash group plans to attack the secular school in Piland on January 1st.

F.2 Offer of information

Any unaltered information offered from one team member to another with little or no interpretation. Any definitions offered as a response to a request.

- ***Earth***: silver doesn't work in piland
- ***Water***: Yeah, fanatical, what does that mean?
  Air: Fanatical just means, uh,…it's just they're prone to doing, uh, crazy things would be the politically correct…

F.2.1 Information untrue or partial truth (sub-node of offered information)

Altering or contriving information and offering it to other team members; removing a piece of information from a factoid before sharing it with other team members; responding "no" to a direct request for specific information when one does have the requested information.

- ***Earth***: The Purple and Brown groups want to attack the interests of Tauland, Zetaland, or Chiland in February. [*factoid reads March*]
- ***Earth***: Train station opening on the 24th. [factoid reads "The grand opening of a new train station in the capital of Omegaland is scheduled for the 24th and will be heavily protected"]
- ***Fire***: Anyone have any information about the control valve?
  Air: The what?
  Fire: The control valve, the control valve.
  Air: Not yet.
  Earth: No.
  Fire: Water?
  Water: I've got nothing. [*Water received a factoid that reads "The new control valve is being installed at the Southern Oil pipeline terminal on August 15th"*]

F.3 Request for information

Any requests for "factual" information obtained directly from a factoid for which interpretation or speculation was not needed. Any requests for the definitions of words found in factoids.

- ***Water***: Do you have any, like, information about the date?

- ***Fire***: What does, uh, chatter mean? C-h-a-t-t-e-r?

F.4 Offer of speculation

Any theories or propositions either about the meaning of factoids or suggestions for what might be the final solution. Any interpretation of factoids or combining of factoids to come to some derived conclusion.

- ***Fire***: Um, I have "The Sapphire group is comprised of former teachers and does not target schools".
  Air: Okay, I think that means it's not Sapphire.
- ***Air***: Okay, well if he can't operate in Deltaland and Indigo and Tan are in Deltaland then, logically, it can't be Indigo or Tan.

F.5 Request for speculation

Asking another team member either what they think the solution might be, in part or in whole, or asking for the reasoning behind an offered speculation. Asking for how one might interpret a factoid was also coded into this node.

- ***Earth***: So, Z on the 10th possible and did we say which month?
- ***Water***: ok so it's going to be in A B or D and an embassy for A B or G.
  Air: Why not embassy in the others?
- ***Earth***: What does this mean? "The heavily protected southern oil pipeline terminal is ocean-based".

F.6 Confirmation

Any verification that a piece of information offered by another team member is shared or correct, or any agreement with a suggested solution, in part or in whole, or interpretation of the meaning of a factoid.

- ***Fire***: I have Silver group has close ties with the media, does anyone…
  Earth: Yeah I have that.
- ***Air***: Okay, I think that means it's not Sapphire.
  Water: Agree.

F.7 Negation

Any contradiction of the correctness of a piece of information offered by another team member, or any disagreement with speculations about the solution, in part or in whole, or interpretation of the meaning of a factoid, made by another team member.

- ***Fire***: And Sapphire, um, some Sapphire is found in Sigmaland.
  Earth: They're *not* found in Sigmaland.

- ***Water***: It has to be a dignitary.
  Air: I think it's *not* a dignitary, 'cause it said "Security forces are providing highly visible around the clock protection to all visiting dignitaries".

F.8 Clarification question

Asking for an explanation about or a repetition of a recently shared factoid or speculation or asking to provide further information about a statement made by another team member.

- ***Air***: The religious schools in Piland are fanatical. So…
  Fire: Are fanatical?

F.9 Clarification response

Responding to a clarification question by either repeating or giving further explanation.

- ***Air***: The religious schools in Piland are fanatical. So…
  Fire: Are fanatical?
  Air: Yeah.

F.10 Cooperation/strategizing

Any statements, either positive or negative, with regards to planning how to go about obtaining the solution or how to work together. Offering trades of information. This includes also refusals of requests for help.

- ***Air***: let's collaborate better this time – post info on postings board
- ***Air***: Want to swap a clue for a clue?

F.11 Uninformative response

Responding to a question in such a way as to not advance the team closer to finding the solution.

- ***Earth***: Is it December or October?
  Water: I don't know.

F.12 Rule clarification

Any statements or questions with regards to the rules of the game itself or about the use of the PLATT program.

- ***Water***: I think we can all get points, but in the end, either Earth, Air, Fire, or Water is going to get $500.

This category was not included in the calculation of the total interactions because these statements were only captured amongst face-to-face participants. Participants were asked to only submit answers to Headquarters and not questions. Rather, if they had questions they were to simply ask the experimenter. While these questions were captured in the face-to-face condition, they were not captured in the distributed condition because those sessions were not videotaped.

F.13 Miscellaneous

Any discussion between rounds that did not involve strategizing for the next round. This included discussion about the answer to a previous round once the round is over. Any repetition of parts of a statement by another team member that does not advance the team to the solution. Talking quietly to one self. Other “filler” statements such as “oh” or “um”. “Yeah” was also included in this category if it did not appear to fit into any of the other categories.

This category was not included in the calculation of the total interactions for two reasons. Firstly, the interaction between rounds was only possible for the face-to-face participants since the PLATT system was not available to the physically distributed participants and they were asked to not interact verbally. Secondly, vocalizations such as repetitions and fillers also favoured the face-to-face participants. Therefore, this category was not equally representative across conditions.

List of symbols/abbreviations/acronyms/initialisms

Ans.	Answers submitted
β	Beta coefficient
C/S	Cooperation/Strategizing
CAF	Canadian Armed Forces
CMC	Computer-Mediated Communication
Con.	Confirmation
CQ	Clarification Question
CR	Clarification Response
d	Cohen's d (effect size)
Dc	Distributed condition
df	Degrees of freedom
DND	Department of National Defence
DRDC	Defence Research and Development Canada
DRDKIM	Director Research and Development Knowledge and Information Management
DV	Dependent Variable
FtFc	Face-to-Face condition
HR	Highest Rating
HREC	Human Research Ethics Committee
IQR	Inter-Quartile Range
KF	Key Factoid
LR	Lowest Rating
M	Mean
Mdn	Median
MLM	Multilevel Modeling
N	Number
Neg.	Negation
n.s.	Non-significant
NF	Noise Factoid
OI	Offer of Information

OR	Others' Rating
OS	Offer of Speculation
p	Probability
PIQ	Post-Interaction Questionnaire
PLATT	Planning Task for Teams
R&D	Research & Development
RI	Request for Information
RS	Request for Speculation
SD	Standard Deviation
SE	Standard Error
SF	Shared Factoid
t	t-test statistic
TC	Total Correct
TI	Total Interactions
U/P	Untrue/Partial truth
UR	Uninformative Response
χ^2	Chi-square statistic
z	z score
z_U	z score calculated from Mann-Whitney U statistic

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The tendency for organizations, including the Canadian Armed Forces, to solve problems using meta-teams, or teams of individuals from various organizations, has created a need to understand the nature of collaborative performance within potentially competitive climates. While the use of meta-teams allows members to draw upon diverse experience and expertise not available within one organization, creating a potentially more efficient mechanism for dealing with tasks or solving problems, individual members may place the needs of their home organization above what is best for the meta-team, creating a potentially competitive environment. Distributed teams, in particular, may face challenges in developing the relationships amongst meta-team members that are necessary for effective meta-team collaboration. Thirty meta-teams of 4 participants, each of whom was assigned to one of four higher-order groups (akin to home organizations), worked on a series of problem-solving tasks that required at least some level of elicited cooperation in order to be successful. Half of the teams worked face-to-face and half of the teams used computer-mediated communication only. Points were awarded to individual participants based on whether and how the problem was solved (i.e., as a team or alone). Participants' coded interactions as well as their post-interaction ratings of their meta-teammates were assessed using non-parametric tests and multilevel modeling. The results indicated that distributed and face-to-face meta-teams were equally effective when it came to solving the problems, but that the nature of the problem solving was dependent on the nature of the team. Face-to-face teams were much more collaborative in their work and were also much more likely to have positive views of each other. However, face-to-face team members who over-shared their information and asked many (often repetitive or redundant) questions created confusion amongst their teammates, and a fixation on certain information, thus making it less likely that they would be successful in their attempts at problem solving. Although subject to further validation, these results point to behaviours that may be useful when attempting to establish an effective meta-team working environment.

La tendance pour les organisations, y compris les Forces armées canadiennes, à résoudre des problèmes à l'aide de méta-équipes ou d'équipes de personnes provenant de diverses organisations a suscité le besoin de comprendre la nature du rendement collaboratif dans des milieux où il peut y avoir de la concurrence. L'utilisation de méta-équipes permet aux membres de s'appuyer sur une expérience et une expertise diversifiée qui ne sont pas toujours présentes au sein d'une même organisation. Cela permet de créer un mécanisme de traitement des tâches et de résolution de problèmes qui peut se révéler plus efficace. Cependant, il se peut que des personnes favorisent les intérêts de leur propre organisation d'attache plutôt que de rechercher ce qu'il y a de mieux pour la méta-équipe, créant ainsi un milieu où il peut y avoir de la concurrence. Les équipes réparties, en particulier, peuvent se heurter à des difficultés lorsqu'il s'agit d'établir des relations entre les membres de la méta-équipe, relations nécessaires à une collaboration efficace. Trente méta-équipes de quatre participants, chacune d'elles affectée à l'un des quatre groupes d'ordre supérieur (s'apparentant aux organisations d'attache), ont travaillé à un ensemble de tâches de résolution de problèmes qui nécessitaient au moins un certain niveau de collaboration pour assurer leur réussite. La moitié des équipes ont travaillé face à face, alors que l'autre moitié n'a utilisé que les communications électroniques. On a accordé des points à chacun des participants en fonction des aspects suivants : la résolution du problème et la façon dont il a été résolu (c.-à-d., en équipe ou par une seule personne). On a évalué les interactions codées des participants et déterminé le classement après les interactions de leurs coéquipiers de la méta-équipe à l'aide de tests non paramétriques et de modèles à niveaux multiples. Les résultats montrent que les équipes réparties, tout comme les méta-équipes travaillant face à face, ont été efficaces lorsqu'il s'agissait de résoudre des problèmes, mais que la nature de la résolution dépendait de celle de l'équipe. Les équipes face à face travaillaient davantage en collaboration et étaient plus susceptibles d'avoir une perception positive les unes des autres. Cependant, les membres des équipes face à face qui échangeaient trop d'information et qui posaient de nombreuses questions (souvent répétitives ou redondantes) suscitaient la confusion chez leurs coéquipiers et les amenaient à fixer leur attention sur certaines informations. Ils étaient ainsi moins susceptibles de parvenir à résoudre les problèmes. Même s'ils doivent faire l'objet d'une nouvelle validation, ces résultats indiquent les comportements qui pourraient être utiles lorsqu'on tente d'instaurer le milieu de travail d'une méta-équipe efficace.

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