In-group/Out-group Effects in Distributed Teams: An Experimental Simulation

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ABSTRACT
Modern workplaces often bring together virtual teams where some members are collocated, and some participate remotely. We are using a simulation game to study collaborations of 10-person groups, with five collocated members and five isolates (simulated 'telecommuters'). Individual players in this game buy and sell 'shapes' from each other in order to form strings of shapes, where strings represent joint projects, and each individual players' shapes represent their unique skills. We found that the collocated people formed an in-group, excluding the isolates. But, surprisingly, the isolates also formed an in-group, mainly because the collocated people ignored them and they responded to each other.

Categories and Subject Descriptors
H.1.2 User/Machine Systems, *Human factors;* H.5.2 User Interfaces, *User-centered design.* H.5.3 Group and organizational interfaces, *collaborative computing.* K.4.1. Public policy issues, *Privacy.*

General Terms
Human Factors

Keywords
Distributed group work, distant collaboration, computer-mediated communication, collocation, telework, telecommuting, virtual teams.

INTRODUCTION
The advance of information technology has introduced more distant collaborations than ever before. Multinational companies outsource key business functions to companies overseas. Companies create virtual teams of their own employees that bring together geographically dispersed workers with complementary skills.

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This ongoing trend sees companies accommodate more variations of telecommuting, including hiring employees from different states or different countries, and expecting them to collaborate effectively with colleagues in faraway offices.

There is no mystery as to why these innovations are occurring—they are made possible by rapid advances in technology including electronic mail, deregulated long-distance telephone, shared online file-spaces, videoconferencing, instant messaging, and web-enabled application sharing.

There remains some mystery, however, as to how to get maximum benefit from long-distance collaborations. Despite the wealth of technology available, distant collaborations still face formidable barriers [19]. Recent research on international software development is illustrative of the kinds of problems that hamper distant work. Herbsleb and colleagues studied three divisions of a single corporation, located in the U.K., Germany, and India, as they collaborated on integrated and time-sensitive software development projects. Within these distributed teams, it was found that requests for modifications in software took longer whenever they involved engineers in multiple locations [15]. These engineers also reported sharing less personal information, and having less of what is called 'affective trust' [17] with their distant colleagues [23]. This difference in trust inhibits collaboration when projects faced uncertainties, crises, or interpersonal conflicts. When misunderstandings arose between people in different locations, they seemed more likely to disrupt workflow, cause more negative feelings, and were more difficult to smooth over at a distance.

Some aspects of long-distance collaboration are well-researched. We know a lot about how small groups of people communicating via video, phone, email, or other computer-mediated communications will perform on a variety of tasks. Interestingly, the majority of experimental studies find no difference in peoples' ability to perform short, well-defined experimental tasks using synchronous communication such as video or audio conferencing. (See Finn, Sellen, & Wilbur [13] for a review). Some particular tasks that require negotiation [8], trust, [5] or communication across language barriers [27] are affected by media choices. However, previous lab work does not completely explain field findings, and much is still unknown. Given the range and variety of long-distance collaborations being attempted, and the persistent difficulties of some of these experiences [19, 20] there is much work left to do.

1. FINDINGS FROM PRIOR RESEARCH AND HYPOTHESES

Our area of current interest is in mixed-media groups. When media is used in real-world settings, it is often distributed unequally. For instance, it is a very common meeting format to have several co-workers together in a room, and one or more others joining by telephone. Virtual teams are often partially collocated, with a few co-workers permanently located in a 'hub' location, and the rest joining as individuals. Very often, a manager or key decision-maker will be located at the most central location, along with key administrative personnel or other resources. Collocated groups are known to be very effective in exchanging information and coordinating work [26] but what happens when only part of a group is collocated? We have seen in the field some complex group dynamics arise in mixed-media situations which are not well-described by previous empirical work.

1.1 In-group and out-group effects

There are many interesting psychological dynamics that may arise in different configurations of local and distant collaborators. One that is of particular danger for unequally distributed teams is the dynamic of in-groups and out-groups. Social psychologists have long recognized the tendency for small groups to form group identities, and begin exhibiting in-group behaviors [6, 16]. In allocating scarce resources, members tend to distribute resources in ways that favor the in-group, and neglect the out-group [12]. In-groups can be beneficial when they include the entire company or functional team, promoting team spirit and individual self-esteem [25]. But when in-groups form *within* a team, they can be a drag on efficiency and morale [18]. Even meaningless and arbitrary methods of dividing people into groups tend to encourage in-group versus out-group dynamics [25], and once this process is started, individuals will often exaggerate perceived differences between groups to further the formation of group identity.

There seems to be a tendency for distributed teams to form subgroup identities based on location. Shared location provides a natural basis for the development of strong subgroup identities because such clusters of people typically enjoy more interaction and share more information with each other than they do with remote partners [11]. A number of empirical studies of remote work support this claim. Armstrong and Cole studied software development teams and found that location was the basis for group identity among team members. They noted frequent instances where team members of the same site referred to each other as 'us' while referring to team members at other sites as 'them' [1]. Herbsleb and Grinter describe a competitive environment based on location that created subgroups in a software development team distributed between two sites in Germany and Britain. The fear that one site might be shut down and work consolidated in the other site led to weak information sharing across sites and strong in-groups within sites [14]. Cramton studied students assigned to do a team project across national boundaries and found that team members were reluctant to interact with remote team members because of inconvenience factors such as the time and effort required [10, 11]. This led them to increasingly interact with members that were only physically collocated with them.

In addition to field studies, there have been a number of experimental studies done on subgroup formation. These groups form the basis of a cooperation regime. In one study, Buchan and her colleagues [7] found that participants were more collaborative with those that shared the same group membership. Pool [21] found that manipulating the availability of computer-mediated communication channels significantly affected how individuals within larger groups formed coalitions with each other. Using agent-based software models, Cohen et al. [9] and Riolo et al. [22] showed how contextual cues such as physical proximity can lead to the emergence and maintenance of subgroups.

Finally, the Principle of Least Effort suggests that if using computer mediated communication is harder than communicating some other way, people will avoid computer mediated communication. Despite recent progress, there are still important ways that using computer mediated communication is less comfortable and convenient than communicating face-to-face. Participants in computer mediated communication are unaware of contextual activities. Without contextual information it is difficult to know when someone is available or interruptible. Furthermore, people worry about appearing rude, so do not initiate contact or interrupt.

Based on prior research discussed above we hypothesize that

Hypothesis 1: Individuals collocated together will interact more with fellow collocators, and form an in-group.

Hypothesis 2: Individuals that are isolated will form a separate in-group in response to exclusion from the collocator in-group.

Working in close proximity to others is well-understood to promote rapid exchange of information and enhanced productivity [26]. In a meta-analysis of research comparing face to face versus computer mediated communication, groups communicating face to face were found to make faster and more effective decisions than groups using computer mediated communication [3]. Sole and Edmondson studied seven geographically dispersed teams in a multinational company designing and producing polymer products and found that it was relatively easy for team members to access knowledge located in the same site in which they encountered a problem. Accessing knowledge in sites other than where they were located was difficult [24].

Ease of coordination, faster decision making capabilities and easy access to the knowledge of fellow co-workers lead us to hypothesize that

Hypothesis 3: Individuals collocated together will outperform isolates because of their advantage in coordination and membership in the collocator in-group

2. METHOD

2.1 The Shape Factory Simulation

This paper reports data from use of the Shape Factory simulation environment. This experimental task was designed to study collaboration patterns among groups in many configurations across unequal media (face to face vs. computer mediated communication) and unequal geographic distribution (collocated vs. remote).

The simulation is an online multi-player game involving ten players. Each player represents a particular color-shape combination, e.g., Blue Square, Purple Circle. In each round of the game players try to fill 'orders' for strings of shapes, e.g., 'circle-square-diamond-triangle'. Each round a players' orders contain a total of eight shapes. The two main actions of every player are trying to buy shapes from other players in order to assemble orders, and trying to sell their own specialty shape to others.

Each player can produce their own specialty shape at a low cost. (E.g. Blue Square can produce cheap squares.) Players can also produce other non-specialty shapes, but at a high cost, so it is to a player's advantage to try to buy non-specialty shapes from others who make it cheaply. Players' orders never include their own shape, so players usually try to buy all eight shapes that they need from others.

Each player can produce a maximum of six of their specialty shapes each round to sell to other players. Since each player wants to buy eight parts, but can only produce six each round, there is some scarcity and some social pressure in deciding who to sell shapes to.

There are a total of five specialty shapes in the game, and for each specialty shape there are *two* players who can produce it at a low cost. For example, Blue Square has a counterpart, Orange, who also makes and sells squares. Thus, players always have a choice of who they can develop buying and selling relationships.

Each shape factory session was arranged with: 'collocators' and 'telecommuters'. Five collocators work in a single room, and five telecommuters work in individual rooms, as shown in Figure 1. It should be noted that both the collocator and telecommuter groups are self-sufficient, i.e., all five shapes are represented in each subset.

Shape Factory's web interface allows players to request, negotiate, and deliver shapes through its messaging system. Players can also send text messages to other players. For telecommuters, this system provides the only available communication medium. Collocators, who sat around a table in the same room, have the option to communicate verbally across the table, in addition to text messages through the game interface. The interface supports one-to-one bargaining on prices of shapes, but does not allow multi-player auctions.

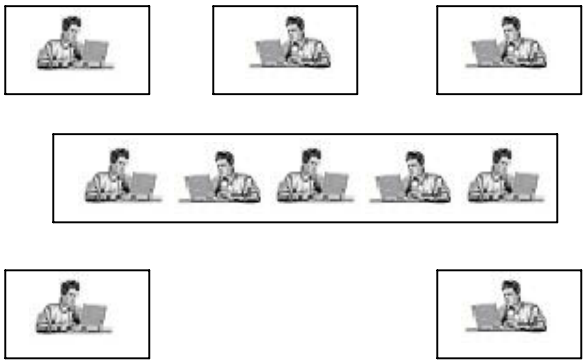

Figure 1: Configuration of five remote and five collocated players in the Shape Factory experiment

The first round of Shape Factory lasted 20 minutes to give players more time to learn the game. Subsequent rounds lasted 15 minutes, in a total of five rounds. This scheme creates some time pressure, although most players do finish their transactions in this time. There is also a shortage of cheap parts since each player needs eight shapes but can only sell six. The combination of time pressure and shape scarcity creates a situation where players cannot afford to be completely generous with their time and resources with all nine potential collaborators; they must prioritize requests.

Players are instructed to maximize their earnings as an individual. They could do this by:

1) selling specialty shapes to other players and
2) assembling purchased shapes into assigned orders.

The outcome measures that we tracked for each player were the game score, which is calculated from profits from filling orders plus profits from selling shapes, and number of shapes bought and sold. We will compare performance of collocators and telecommuters on these measures.

2.2 Corollaries to 'real world' collaboration

As in most simulations, Shape Factory is not intended to be a full simulation of real world collaboration, but rather is intended to reproduce some realistic dynamics of distributed work. The exchange of shapes between players is intended to mimic the way that real-world collaborators exchange time, skilled work, and other favors. For example, programmers working for the same company would have different specialties, and part of their job would be to enlist aid from relevant specialists. A highly efficient organization is one where employees can enlist and direct specialized skills of others without undue cost or delay. Research by Herbsleb, et al. [15] documented how distributed work can be inhibited when geographically separated workers fail to lend their specialized skills quickly. In Shape Factory, the scores of both individuals and the group are a reflection of their ability to enlist collaboration (through exchange of specialized shapes) when needed.

One criticism of the Shape Factory environment is that is it more competitive and less collaborative than most teamwork. This is probably true; in the tradition of experimental research, we have exaggerated the variables of interest in order to study them more effectively. But it is also true that even perfectly altruistic teams still face choices in how they allocate their time, attention, and favors. The interactions of the most well-meaning team may still be affected by the configuration of local and distant team members. And, in the workplace, performance reviews usually focus on individual versus collective performance.

As for the experimental conditions, although we will refer to the two conditions as 'collocators' and 'telecommuters', we know that these also have some unrealistic aspects. Our simulated telecommuters can communicate outside of their rooms only via text messaging. Real telecommuters would at least have a phone available, and probably some ability to travel. For the purposes of this study it made sense to maximize the differences between groups. The point of the simulation is to study the effects of unequal media and unequal geographical distribution, which are very real challenges for telecommuters. Future experiments will add new variations, such as phone, instant messaging, and travel,

and measure the extent to which these variables ameliorate the effects of isolation.

We believe Shape Factory represents a paradigm shift toward more complex and large-scale experiments, which is needed to study phenomena that arise from real-world settings. Shape Factory is by necessity larger and less controlled than a typical experimental design. The effects we are looking for are emergent effects arising from many interacting players, not direct effects of individual actions or intents. For example, we do not expect that any individual in the game will *intend* to ignore or marginalize our simulated telecommuters, but we expect that in a complex and fairly fast-paced game this effect will emerge as a result of many players' actions. We also expect market forces to act in this larger group differently than they might in a smaller group experiment. These effects will emerge (if they do) because the game accommodates many individual choices and many different possible strategies.

2.3 Participants.

We recruited subjects from a subject-recruiting email list and an advertisement posted on a college campus newspaper. A total of 130 people participated in our experiment. Among the participants, 52% were female and 97% were students. Their average age was 22. They had an average of 14 years of education. Over 99% of the participants had used a computer and the Internet for more than three years and used email regularly. Thirty-six people said they knew someone else in their session. Since we randomly chose who would be a telecommuter and who would be collocated, and players used colors rather than their real names to identify themselves in a game, we did not believe their acquaintance would affect the results we would be studying.

2.4 Procedure.

We conducted 13 sessions, each session consisting of five rounds of the game. In the beginning of each game, we gave participants 20 minutes to read the game instructions web page. To make sure that they understood and remembered the instructions, we gave them a quiz once they finished reading and checked their answers afterwards and explained any questions answered incorrectly.

There were 10 players in each session, five 'collocated workers' and another five in five separate rooms working as 'telecommuters' as shown in Figure 1. The labels of 'collocator' and 'telecommuter' were never used with subjects, and in general we tried not to draw attention to the spatial configuration. Participants were assigned to be producers of particular shapes by a random draw. Shapes were also rotated between sessions so that the same shape was not always in the same condition.

Players who were assigned to the collocator group were brought into the collocator's room. Remote participants were escorted to the isolated rooms. As a consequence, collocators could deduce which cheap shapes were available in their room and which were produced by remote players. Remote players knew that they were isolated and that there were five people sitting together in another room, but could not tell which shapes were collocated and which were remote. As previously noted, collocated players could communicate either face-to-face or exchange text messages through the game interface. Remote players could only interact with other players via text messages through the game interface.

Participants received $15 as the baseline payment plus a bonus of up to $10. They earn bonus money for scores of 100 or higher, starting at $1 and adding another $1 for every additional 50 points in their score. This payment scheme gave them an incentive to try to do well, which required them to stay engaged in both buying and selling with other players throughout the game.

For each session of Shape Factory we recorded all text messages and all transactions sent between players. We also observed and took notes on conversations in the collocated room, but were not able to collect usable audio recordings. Analyses were done on players' game score and shape exchange patterns over the course of the game.

2.5 Data sources

The primary data analyzed in this paper are the shapes exchanged between players in these 13 sessions. All shape transfers are logged by the system and stamped with round number and time of transactions. Examining who bought from whom and who sold shapes to whom is our primary measure of collaboration.

We also have post-experiment questionnaires from all players. This questionnaire included five demographic questions, the check for prior relationships between players, five open-ended questions that went to all players about their game strategy, 25 closed-ended questions on game strategy for all players, four Likert questions that went only to collocators, and six likert and one open-ended strategy question that went only to telecommuters. Closed ended questions were designed to assess how much various possible strategies were used. A number of these were checking for unlikely but potentially important strategies, such as price collusion.

The open-ended strategy questions were coded by two raters. The coding categories were devised by one rater who was very familiar with the experiment, who then trained the other rater. Inter-rater reliability using Cohen's Kappa was a very good .85.

Note on prices: When shapes are exchanged, players must agree on a selling price, which in this game varies from around $15 to $30. Although players in the experiment could negotiate prices, most shapes were sold near the median price of $22. There were no important differences in prices between collocators and telecommuters related to the findings presented in this paper, and therefore prices are not discussed in this paper. Analysis instead focuses on the number of shapes exchanged, where there were important differences.

3. RESULTS AND DISCUSSION

Hypothesis 1: Individuals collocated together will interact more with fellow collocators, and form an in-group

Analysis of the trading patterns gives strong evidence to support Hypothesis 1. Collocated team members had a strong tendency to collaborate with each other instead of with the simulated telecommuters.

Table 1 shows the total number of shapes bought and sold between collocators and telecommuters. Configuration had a strong effect, such that collocators bought 64% of their shapes

from other collocators, and only 36% from telecommuters. (Telecommuter tendencies will be analyzed in the next section.)

		SHAPES BOUGHT: Collocators	SHAPES BOUGHT: Telecommuters
SHAPES SOLD	Collocators	1069	583
	Telecommuters	590	1066

Table 1. Number of shapes bought and sold between collocators and telecommuters

We performed a regression analysis to see if these differences were significant. We calculated how many shapes each player had sold to telecommuters and collocators in the course of their game. Regression analysis was used so that we could manage the 'nested data' by controlling for effect of particular experiments. We added each game as a dummy variable to control for possible effects of high and low functioning groups. This analysis confirms the significance of the relationships seen in Table 1: collocators sold significantly more shapes to other collocators, and telecommuters sold significantly more to other telecommuters (Beta=.63, $p<.01$).

Why did this strong trading bias occur? The simplest answer is convenience. Collocators could verbally negotiate deals, which took less time and less effort than arranging sales using the messaging system. Observation of most collocated groups confirmed that these groups did exchange a great deal of verbal information, checking on shape availability ("Hey green, do you have any shapes left to sell?"), negotiating exchanges ("I'll sell you two for 23 each"), and checking up on orders ("Yellow can you send me those shapes that you said you would?"). Shape exchanges still had to go through the messaging system in order to take effect, but the verbal channel, when available, was a useful and preferred supplement to the messaging system.

There may be other social dynamics that reinforced the in-group trading bias of the collocated groups. Social pressure of being face-to-face probably played a role. It was relatively easy to ignore or say 'no' to an email message from an unseen player, but harder to say no to someone sitting across the table.

In the post-experiment questionnaire we asked collocated players two questions related to possible in-room bias. Collocators showed that they were somewhat aware of this bias, although not as mindful of it as the trading data might suggest. To the question "I usually tried to get shapes from players in the room before requesting shapes from players out of the room", collocators' average response was 3.3 on a Likert scale of 1=strongly disagree and 5= strongly agree. When asked whether they were trying to exclude telecommuters, on the question "We tried to trade with players only in our room", collocators tended to disagree, averaging slightly below the midpoint at 2.3.

Observations of the verbal conversations in the collocated room did reveal some typical in-group behavior occurring. Collocated players would compare notes about particular telecommuters, especially ones who were deemed 'difficult'. There were a few coordinated boycotts against telecommuters who were felt to have misled or cheated collocated players. These types of actions suggest formation of an in-group identity in the collocated room, with potentially harmful effects on cohesion and identity formation in the larger group.

We do not think that social conflict was a main driver of in-group effects, however. More likely, they were effects of the lopsided trade and communication patterns. Gossip and retribution behaviors were far from ubiquitous, and occurred mostly in later rounds when in-group patterns were already quite strong. Once the in-groups had formed, it was difficult to break across these barriers, and this probably led to collocators' frustrations in trying to buy shapes from telecommuters and labeling of individual players as 'difficult'. The primary drivers of the in-groups effects were functional; and the social/psychological effects were secondary.

Hypothesis 2: Individuals that are isolated will form a separate in-group in response to exclusion from the collocator in-group.

How did the telecommuters respond to the trading in-group of the collocators? In these experiments, they responded by very quickly and very effectively forming a trading in-group of their own. Table 1 shows that telecommuters showed a very similar trading bias toward other telecommuters as did collocators.

The surprising aspect of this is that the telecommuters were only vaguely aware of their status, and had no effective way of knowing who the other telecommuters were, especially at the beginning of the experiment. It was possible for them to ask other players through the messaging system if they were in a room by themselves, but almost none of them did. In the post experiment questionnaire we asked telecommuters an open-ended question about whether they tried to do anything to compensate for being isolated and, roughly 60% responded 'No'. In the early rounds, players were preoccupied with learning the game and devising an effective strategy and were not paying attention to differences in setting. At the end of the experiment debriefing, telecommuters showed little awareness of room differences.

So how did the telecommuter in-group form, if they themselves were hardly aware of it? It appears to have simply been a response to being ignored. We separated out the first five minutes of the first round of the experiment, and during that time telecommuters sent purchase requests about equally between collocators and telecommuters. They did not receive requests in equal numbers, however, and did not receive responses to their requests in equal numbers. Unbeknownst to the telecommuters, the collocators were negotiating verbally, responding to each other preferentially, and being less responsive to those outside the room. Telecommuters simply responded to the players who responded to them, which turned out to be primarily the other telecommuters. They did this very quickly and efficiently, and by the end of the first round the trading biases were well established.

How did the in-group trading of both groups change over time? One might speculate that this coalition would either take some time to form as collocators got to know each other; or conversely that it might be strongly observed in the early stages of a game but dissipate over time as the distance barrier became less of an issue. Figures 2 and 3 are graphs showing who collocators and telecommuters sold shapes to over the five round experiment. In both cases it shows that the discrepancy in trading was present from the first round, increased markedly in the second round, and continued to grow throughout the experiment.

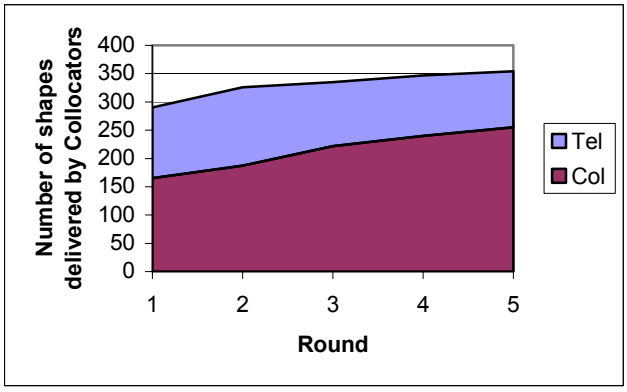

Figure 2 Shapes delivered by collocators

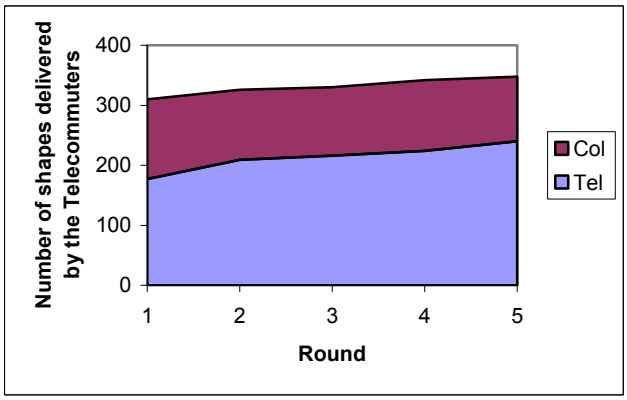

Figure 3 Shapes delivered by telecommuters

Why did in-group trading increase over time? In the post-experiment questionnaire players reported that they used past transactions as a guide for who to buy and sell from. One question asked players to agree or disagree with this statement: "Previous rounds' interactions with players influenced my buying and selling decisions, i.e. I paid back favors, I ignored players". Both conditions tended to agree with this statement, with an average of 3.5 on the 1-5 agreement scale.

There was also a significant difference between conditions on this question. Telecommuters were even more strongly mindful of previous interactions than were collocators, agreeing with the question at an average of 3.8, to 3.1 for telecommuters. ANOVA analysis show that this difference was significant ($df=1, 137, F=12.1, p<.01$).

So, prior history or relationships among players provides a good explanation for the strengthening of in-group biases over time. And surprisingly, it was the telecommuters driving this effect as much as, or more than the collocators, because the telecommuters relied more strongly on past relationships to guide future ones. In the first round telecommuters might have tended to send requests to every player, but as the game went on they focused their attention on trading partners that had come through for them previously. The small first round bias reinforced itself in subsequent game rounds.

Hypothesis 3: Individuals collocated together will outperform telecommuters because of their advantage in coordination and membership in the collocator in-group

Collocated players would seem to have had many advantages in this game. They could coordinate negotiation of prices and trades more quickly and easily than telecommuters. They could potentially learn the game more quickly and adopt more sophisticated strategies by drawing on the other players in the room with them. The game designers and game players alike all expected that collocation would be a considerable advantage. Was it? Surprisingly, it was not, at least not in effectiveness.

There was no difference between average score of collocators and telecommuters. In fact, telecommuter average score was slightly higher, but not significantly. There were also no differences in shapes sold, shapes purchased, orders filled, purchase prices or sales prices. Also, on post-experiment questionnaires there were no differences in how difficult the game was to learn or how frustrating it was. Both group averages were near the midpoint on these items.

One other interesting difference from the post- questionnaires was on the item "I found this game to be fun". The collocator mean was a very high 4.3 on a 5-pt scale, and the telecommuters mean was a slightly, but significantly lower 4.0. ($df=1, 137, F=4.5$ $p<.035$). This is compatible with many other studies where richer communication channels are rated to be more enjoyable, even when they do not lead to performance differences [4]. One might expect 'fun' to link to performance in longer tasks where less engagement might lead to less motivation. This was a fairly long game as experiments go, but did not show such performance differences. It is worth speculating, however, that in a real-world setting where telecommuters worked on their own for months or years, differences in enjoyment might eventually lead to perceptible performance differences.

4. DISCUSSION

The results of our study regarding the formation of in-groups among collocated and remote players are consistent with previous findings of field studies of subgroup formation based on location in distributed teams. Perhaps the most interesting finding of our study is the creation of an in-group among telecommuters, without them even knowing who was a telecommuter and who was not. Telecommuters were neglected early on by collocators, and quickly formed their own unwitting in-group in response. Once this in-group dynamic was established, it perpetuated and strengthened because players tended to continue to rely on the same players who they had collaborated with in the past.

These experiments illustrate one of the dangers of mixed-media teams, which is the danger of in-group and out-group dynamics forming within teams. Unlike previous field studies, which are confounded by group history, local culture, or other such variables, the effect here is solely due to different communication media access. Because of the speed with which these groups formed, it does not appear that these groups arose primarily because of gossip, insecurity, imagined slights between groups, etc. Instead these functional in-groups arose and were reinforced by players taking actions that were individually rational. This type of rapid, almost invisible in-group formation should be particularly worrisome to managers of partially-distributed teams.

One characteristic of our experiment that made in-groups possible was that the groups could operate relatively independently. Each condition had every 'shape' represented and thus could form an effective in-group. We have already conducted experiments where this was not the case, and interesting dynamics do occur (results in-progress). Another characteristic was the lack of a single manager, lack of opportunity for whole-group discussion, and the lack of strong group awareness of the potential for splits to occur. (These are all possible interventions that we will explore in future studies.)

What kind of teams are in particular danger of in-group/out-group effects? When conditions similar to our experiment exist, mixed-media teams may be quite vulnerable. And it is not just partially collocated teams that are in danger; any team that has multiple available communication channels should be mindful of how they are used. Our experiment used the two communication channels of verbal and text messaging, but there are other possibilities. In-groups could easily form when one part of a fully-virtual team is in a particular time zone and relies on synchronous communication (phone, instant messaging) and the rest are in a different time zone, or many time zones. These effects could also happen when half of the team has adopted a particular technology—say, instant messaging—and the other half has not. It could happen when one part of a team joins video meetings with a high-bandwidth video connection, and the others have jerky, low bandwidth access to the same meeting. Any time multiple channels are used in parallel, danger exists. One author took part in a project where there were regular teleconferences that everyone attended, but part of the group (the lower-status student members) held a parallel conversation via instant messaging. While entertaining, this also often led to parallel conversations and negative group dynamics.

These possibilities suggest that more communication technology options are not always better. Often new technology suites offer a wide variety of tools (IM, IP audio, email lists, bulletin boards, real-time document sharing, etc.) When adopting such suites, virtual teams might be best advised to settle on a small toolset, and have one communication channel (e.g. email) be the privileged source that people can count on for important news to prevent fragmentation of communication.

The second finding of interest from our experiments was the lack of difference in performance between collocators and telecommuters. We expected that collocators would use their ability to coordinate transactions and follow-up verbally, which they did. But we were surprised by how well and how quickly the telecommuters used their advantages to compensate for being isolated. The telecommuters in our study were alone in a room and could play the game without any interruptions. As a result they could allocate all their cognitive processes to the game. Players collocated in the room were constantly asking for shapes and receiving offers for their shapes all in multiple ongoing conversations. Observations of the collocated room revealed that when a player was in the middle of requesting shapes from a fellow player, they would often be interrupted by the other players asking for shapes or following up on previous negotiations. Telecommuters, meanwhile, could fully concentrate on the task at hand. They did not have to deal with social pressure or unwanted verbal requests; they could respond to who they wanted when they wanted.

We are not the first researchers to be surprised by high-performing telecommuters. A review of more than 80 empirical studies of telework [2] concluded that there is little evidence that being remote has any significant positive or negative effect on performance. Interestingly, this review also showed that the most common reason given for telecommuting was the ability to concentrate, over and above more often-cited reasons such as home/life balance or avoiding long commutes. Our research adds to the evidence that concentration and focused attention are advantages that should not be underestimated.

5. FUTURE DIRECTION

We are currently preparing several more papers using this dataset. We are analyzing message content and collocated discussions to try to characterize the different communication 'cultures' that arose in collocated and telecommuter in-groups. We are also using agent-based modeling to try to understand better the strategies of players in this game, and hopefully be able to model how this game would play out in other situations, such as larger groups or more locations.

This research is the beginning of a line of research on large groups involved in mixed-media collaborations. We hope that this type of experiment will allow more exploration into the dynamics of these types of groups, and also allow exploration of interventions that may ameliorate effects of mixed media. Interventions we plan to test include social interventions, simulated travel, richer media channels, and group-level performance bonuses. We plan to make the Shape Factory simulation publicly available for researchers to utilize in exploring questions pertinent to distributed collaboration. This can be a useful addition to the 'tool box' of CSCW researchers.

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