Exploring collaboration in group-to-group videoconferencing

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Abstract Prior work on videoconferencing shows that various design changes can have profound impacts on group dynamics. In order to further explore the available design space, we report on a qualitative study that compares behaviour of groups in two group-to-group videoconferencing environments and face-to-face communication during a complex social dilemma game. There are pronounced differences in participant behaviour between the two videoconferencing designs, indicating higher cooperative behaviour in one of the videoconferencing conditions. Based on qualitative analysis of the gameplay, we hypothesise that the decisive factor is a discrepancy in the type of group identity that develops during the game. Our results suggest that the differences in behaviour are due to differences in design of the two videoconferencing environments. In particular, the incorporation of personal displays and individualised videostreams likely contributed to these outcomes.

1 Introduction

Videoconferencing is coming into focus of researchers and industry again, both in the context of workplace (e.g., [12, 16]), as well as everyday life (e.g., [1, 7], and success of Skype as a family video chat). A number of recent studies shows how often even subtle changes in the design of videoconferencing systems strongly affect interaction of users [11, 9, 10, 16, 18, 12].

A common scenario for distributed interaction in the workplace is *group-to-group* communication, where several people are collocated at a number of distributed sites. While this has not been so extensively researched by the videoconferencing community, previous studies have found that specific problems arise when computer-mediated communication (CMC) channels such as email, chat, audio or

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commodity videoconferencing are used in this setting. For example, groups might exhibit strong in-/out-group effects on each site [5], leading to *collocation blindness* [4] or *presence disparity* [15]. Efforts to support group-to-group communication through specialised video conferencing environments appeared [9, 18, 12], reporting significant improvements over the commodity videoconferencing design (i.e., units consisting of a large shared screen and camera per group such as Cisco TelePresence series and similar). These specialised environments are based on various design factors, such as individual viewing positions allowing for eye-contact [9], "blending" of physical spaces by careful choice of furniture and camera angles [12], or effects of seating arrangements [18]. Moreover, all design concepts above build on technically complex solutions and include components that are not directly accessible to many users.

To inform further development of group-to-group videoconferencing environments, it is important to understand these design factors much better, as well as analyse how they play out in various settings. To explore this design space, we have previously developed a group-to-group videoconferencing prototype called GColl [14]. As some form of gaze awareness has been implicated as an important factor in most of prior videoconferencing work (e.g., [10, 18]), we aimed to design for a compromise between supporting gaze-awareness, individual viewing positions and ease of deployment. In comparison to commodity videoconferencing, GColl design includes a screen for each user (e.g., a personal laptop), a videostream from each user (instead of one shared videostream from each site) and a restricted gaze awareness functionality.

In this study, we were interested in exploring if and how the behaviour of groups of participants using GColl differs in comparison with face-to-face interaction (FTF) and commodity videoconferencing design. Our choice of face-to-face and commodity videoconferencing as the two comparison environments allowed us to draw out any gross differences in participants' behaviour over these dissimilar conditions, as well as highlight design choices that provide benefits over the commodity videoconferencing. We adapted a complex social dilemma game as the basis for interaction, with no restrictions on interaction among participants. Lessons learned from such open ended observation help us inform future work and suggest factors that merit further analysis.

In particular, qualitative analysis of the game play revealed pronounced differences in participant behaviour among the two videoconferencing designs and face-to-face, indicating higher collaboration and cooperative behaviour in GColl videoconferencing condition and face-to-face. Based on gameplay analysis, we propose that the decisive factor is a discrepancy in the type of *group identity* that develops during the game. GColl design seems to have facilitated creation of shared group identity similarly to the FTF condition, diminishing the in-/out-group effects observed in groups using commodity videoconferencing, and thus leading to better cooperation among the group members. Contrary to expectations, the observed differences were not due to the gaze awareness affordances available in GColl. In the Discussion section, we suggest how the remaining differences in design between

GColl and commodity videoconferencing (i.e., personal screens and videostreams) could have contributed to the observed results.

The differences in observed behavior between the two video mediated communication outcomes highlight the significant impacts that design choices have on the use and performance of communication systems. Our analysis suggests that the combination of two specific design factors is most likely responsible for these outcome differences, due to facilitating a shift in the group dynamics. One of the contributions of this study is this illustration of the ways such design choices impact the observed use of two comparable video communication systems. Overall, our results do not dispute the importance of gaze awareness for remote collaboration, but point to other aspects that may be also important, such as design dependent changes in group identity.

In the rest of this chapter, we first outline the related work. We continue with description of the study design and the analysis of the gameplay videorecordings. The discussion then ties our observations to the proposed changes in group identity.

2 Related Work

In addition to work already mentioned in the Introduction, a number of previous papers focused on various aspects of the interface and how they affect interaction of users. For example, [11] shows that including the whole upper body rather than a head image increases subsequent helping behaviour towards a stranger. Several videoconferencing systems supporting multi-person (but not group-to-group) interaction explored effects of facilitating gaze awareness and other non-verbal information (e.g., Hydra [13]). Venolia et.al. [16] show how providing a dedicated physical proxy used for videoconferencing in collocated teams with a single remote collaborator improves the felt presence in meetings.

Designed specifically for group-to-group interaction, Multiview system [9] was shown to support trust more successfully than commodity videoconferencing, yielding results that were statistically indistinguishable to those achieved by face-to-face communication [10]. This difference is attributed to gaze awareness Multiview provides and commodity videoconferencing does not. Seating positions together with support for directional gaze awareness and non-verbal signals improved task outcome and discussion structure in [18]. Similarly, contemporary top-end videoconferencing installations, often dubbed as telepresence, (e.g., [12]) report supporting collaboration better than commodity videoconferencing.

3 Method

As discussed above, the study aims to explore differences in behaviour of groups using three communication environments: an environment analogous to current com-

modity solutions (denoted as *standard videoconferencing* – SVE), a prototype design called *GColl* [14], and *face-to-face*. We first give a detailed description of the chosen task. We then go on to provide further details about the used videoconferencing environments and the study procedure.

Task description

Our choice of social dilemma game is motivated by prior work showing that these types of tasks are (i) sensitive to changes in communication environments (e.g., [3]), and (ii) tap into concepts as collaboration and trust that are important for remote teamwork [6]. Similarly to previous research using social dilemma games in CMC (e.g., the Daytrader Game [10, 3]), we used a more complex social dilemma than the well known game-theoretic tasks such as the "Prisoner's Dilemma". To simulate a broader range of real-world interactions, we were interested in a task that retains most properties of common social dilemma games, but allows for long term planning and imitates prolonged group interaction by adding a relationship between the history of actions and the current game state (in contrast with repeated trials of the same situation used in many more formal social dilemma tasks).

To this end, we have adapted a game called The Goldminers, used for example in social skills courses. The Goldminers game is an instantiation of a social dilemma, which forces each player as a group member into the decision between the two basic strategies each turn: she can either cooperate with the other group members, which may not be optimal for her personal score, or defect to possibly gain a higher score than the others. In addition, Goldminers allow for two possible end-game scenarios (cooperative vs. individualistic). These scenarios are based on the end-game score achieved by the group members and impact distribution of rewards after the game.

Goldminers differ from game-theoretic social dilemmas in several ways: first, no restriction on communication is given; second, there are three possible actions to be taken and their effect differs depending on the context; and finally, payback for individual actions changes (in a predictable and known way) during the course of the game depending on the history of previous moves. These differences make the game problematic to analyze by quantitative methods – for example, possible outcomes of one rounds are dependent on the rounds and actions played previously. However, it makes the game more interesting for the participants[1], as well as demanding higher cooperation among the players should they try to achieve the cooperative scenario, as a quite complex strategy needs to be created early in the game if the group is to succeed. Moreover, the motivation for these changes comes from real-world activities, where team communication is key and history of actions done affects the current situation. As our study aims for qualitative understanding of behaviour differences among the environments, difficulties with quantitative analysis are not an issue.

[1] For example, more than half of our groups played a second round of the game "just for fun".

The rules of the game are as follows: Participants represent goldminers and try to mine gold from a river. The river has an attribute called *gold density*, which is set to $30,000 at the beginning of the game. Every round, each participant simultaneously chooses one of three possible actions: (i) **legal mining**, which gives the participant lower personal profit (current value of *gold density* minus 25 % tax) and causes no harm to the others; (ii) **controlling** the river costs the participant a small amount of gold ($15,000 divided evenly among all participants controlling that round) while incurring a great loss to all illegal miners; (iii) **illegal mining** makes the participant either loose or gain $50,000 depending on whether a control action had been played that turn. In both cases, *gold density* attribute is decreased by a $1,000 for each illegal miner. Once every three rounds the river partially "cleans itself", increasing the attribute by a $1,000, up to its original value of $30,000. Once all participants choose their action, the round is evaluated and the numbers of particular actions taken (but not who actually took them) are displayed. The game ends after 15 rounds, or if the *gold density* attribute is ever lower than $1,000. Participants were aware of the exact game ending conditions.

Two ending scenarios were possible: (i) a *cooperative scenario* is achieved if at least 5 out of 6 participants have more game money than a given threshold ($330,000) when the game ends – participants were awarded with a chocolate bar each for this outcome; (ii) *individualistic scenario* was acquired in all other cases – group members were given chocolate bars according to the game money gained (first two participants got two bars, the next two got just one bar, and the last two did not receive any chocolate bars). Thus, incentives for cooperative as well as uncooperative play were present. Note that the overall number of chocolate bars for the whole group remained constant in both scenarios and the only difference was in how they were distributed. The cooperative scenario threshold was chosen so that the group had to cooperate extensively to reach it. Several forms of cooperation are possible in the Goldminers game: the most common one is if everyone in the group agrees to play a particular action. Highest score for each player is achieved if all participants play only legal mining moves for the first ten rounds, and continue with illegal mining till the 15th round.

A simple Goldminers application was developed in Java.

Videoconferencing environments

The study compares three communication environments for interaction of groups: the *standard videoconferencing environment*, the *GColl* environment, and *face-to-face*. The standard videoconferencing environment uses a single screen and camera for each group, resulting in setup analogous to the one shown at Figure 1. Diagram of the setup for FTF condition is at Figure 2.

There are several differences between GColl [14] and the "standard" commodity videoconferencing system: (i) in GColl, each user uses her own display; (ii) there are two cameras aimed at each user (called *focus* and *side* cameras), plus one *group* camera per each site. Additionally, each user can, independently of others,

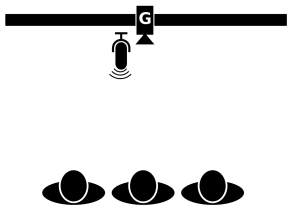

Fig. 1 SVE site configuration

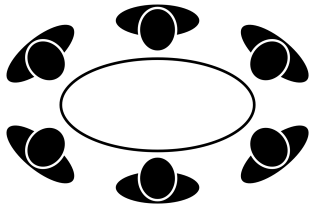

Fig. 2 FTF site configuration

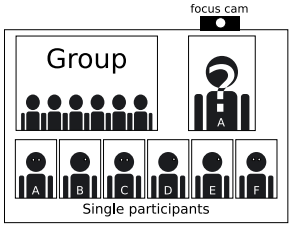

Fig. 3 GColl display layout

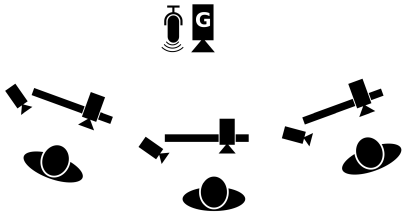

Fig. 4 GColl site configuration

"focus" on any other participant on her display, which was designed to enhance gaze awareness functionality. However, participants in this study did not find the "focus" function useful and have not used it during the game. The explanation was that the game required mainly addressing all others at once, so there was no need to "focus" on a particular player. Due to space restriction, we refer the reader to [14] for details on the intended gaze awareness functionality and other details regarding GColl. Diagrams depicting screen and GColl site layout are at Figures 3 and 4.

Subjects and study procedure

Overall, 126 participants (i.e., 21 groups of 6) took part in this study. Similarly to prior work on social dilemma games (e.g., [4]), we made sure that participants did not know each other prior to the experiment. All participants were students of various national universities and fields of study, and received a small, non-monetary reward for their participation in the study. We asked about previous use of other videoconferencing software: no participant indicated any experience more than "using Skype once in a while".

Each group of six participants communicated over a particular communication channel (i.e., 7 groups per channel), using the Goldminers social dilemma game as the basis for their interaction. We videotaped their communication and logged the progress of the game. In computer-mediated settings, the participants were divided into two 3-person groups communicating over the videoconferencing environment. Each group has participated in one session only.

Technical setup was as follows: All users were provided with a laptop with widescreen display or a PC with a 17" LCD, running the Goldminers applications. GColl users were captured by two Logitech QuickCam Pro 9000 USB webcams at each workstation. At both sites, the group view was captured by an Elmo PTC-15S camera. The game application did not obstruct any GColl windows. In the "standard" videoconferencing setting, the group camera and the sound were captured exactly in the same way as in GColl, and an NEC MT1060 projector was used to display the remote group. The screen was located in front of the seating arrangement, approximately 2m from the participants, placed at a height corresponding to a normal sitting position. The image of the remote participants was slightly smaller than life-size. The same audio setup was user in both videoconferencing conditions: by a ClearOne AccuMic PC microphone at one site and SHURE EasyFlex EZB/C microphone at the other.

Participants in each group played one fifteen-round session of a social dilemma game called Goldminers and attended a debriefing. Each session took 60-90 minutes, depending mainly on the length of gameplay (5-25 minutes, mean 14 minutes). An explanation of the game rules was given by the facilitator with a time for questions, and the participants tried out the game application. Care was taken not to inform the participants about the aims and indicators of the study. Participants consented the game could be logged and videotaped. In computer mediated conditions, the facilitator first explained features of the environment on a running instance. Participants were divided into two subgroups of three, and one of these subgroups moved into another game room. After we made sure that the videoconferencing environment and the game application worked correctly, the participants were left alone to play the game. In the face-to-face condition, the group played together around a large oval table in one of the rooms. A technical team was prepared to help in case any issues arose. When the game ended, we led the participants back to the first room. Additionally, participants from the last 6 groups attended a short focus session. Afterwards, we handed out the rewards: an USB flash disk or a chocolate bar to each player, and 6 additional chocolates split among players depending on the game outcome. The session ended with a voluntary debriefing.

Methodology

Two of the authors and one of their colleagues conducted thematic analysis of the video-recordings, alternating periods of independent interpretation of the data with joint discussion and merging of the proposed concepts. We iteratively annotated the videostreams (using Advene tool [2]) in dependence on the emerging concepts, transcribing relevant parts in detail. The resulting coding scheme addressed the types of discussion for each round – see next section for more details. The analysis was carried out by two of the authors. Additionally, 9 of the 21 videostreams (approx. 42% of the data) were independently coded by an additional researcher. Interrater agreement was 100%, showing that the concepts were clearly identifiable in the data. Due to technical problems, video from one FTF group was not available – overall, video-recordings of six groups using FTF, seven using SVE and seven communicating over GColl were analyzed in this section.

4 Results

Thematic analysis of the video-recordings showed profound differences in behaviour of groups using different communication environments during the task, pointing our attention to the topics presented below: We first outline analysis of the discussion structure, strategies used, and the value groups attached to cooperative play. Second, we present indices of in-/out-group behaviours that appeared in most SVE groups, but very few GColl or face-to-face groups. The Discussion section then suggests an interpretation of the observed differences in behaviours in terms of changes in the type of group identity created.

Strategies and Discussion Structure

We analyzed the gameplay discussion for each group. Initial analysis pointed to differences among the three environments in both the amount of game-oriented discussion as well as the type of proposed strategies, with GColl groups showing behaviour much closer to FTF than SVE groups. In particular, we focused on occasions where a discussion of a joint strategy for the following round(s) took place, if it was accepted and adhered to by the participants, and what kind of strategy was discussed (e.g., long-term vs. just for the current round)[2].

Figure 5 gives an overview of how each group behaved during the game: each 3x15 grid corresponds to a particular group, with rows representing types of discussion present, and columns particular turns. Squares in the lowest rows (red) are filled if any kind of game oriented discussion was present in that turn; the middle row (yellow) is marked if the group came to an agreement on how to play for that round; the squares in the top row (green) are filled if the group adhered to the agreement exactly. Half-filled squares represent rounds where the group explicitly agreed on playing arbitrary actions; gray parts of the two SVE games show turns that were not played as the game ended prematurely due to heavy illegal mining. A star attached to a group name symbolizes that the group reached the cooperative scenario. Similarly, a brown "chocolate bar" symbol next to a group name marks two GColl groups that reached a cooperative outcome in a special way, as discussed later in this section.

We now present a brief description of main differences between FTF, GColl and SVE in terms of used strategies. *Face-to-face groups* are characterized by abundance of strategy oriented discussion, which always started before the first turn and was often long-term (for five out of six groups). Except for one group, FTF-5, participants followed the accepted strategy in the majority of rounds. This group is actually the only FTF group not reaching the cooperative scenario ending. *GColl groups* were generally similar to face-to-face in terms of the tendency to discuss the

[2] Initially, we have also looked at the amount of technical coordination connected to the game application used, social talk such as jokes or other remarks that were not directly connected to the game, and other similar concepts; however, none of these features differed substantially among the environments.

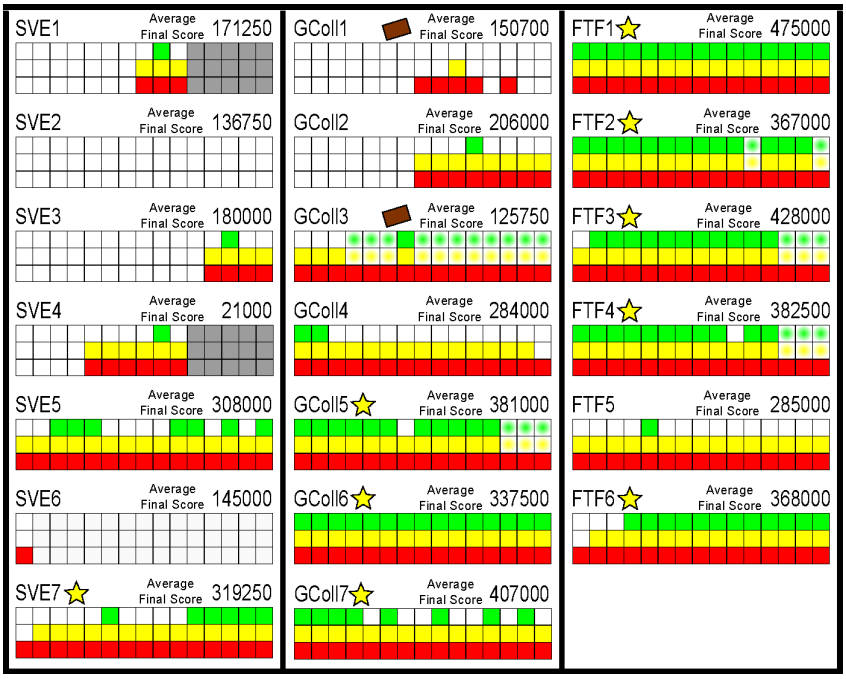

Fig. 5 Round-by-round overview for SVE, GColl and face-to-face groups.

gameplay from the first round and agree on long or short-term strategies (five out of seven groups), even though the discussion starts later into the game in two cases. Although the ability to keep agreements is lower when compared to FTF (but still higher than SVE), most of the groups continued trying until the end.

Two GColl groups that did not create long-term strategies (i.e., GColl-3 and GColl-1), repeatedly discussed a meta-strategy: the participants noted that as the number of chocolate bars handed out in both possible end-game scenarios is equal, it does not matter whether they manage to "formally succeed" (i.e., end the game cooperatively) as they can always redistribute the chocolate bars themselves to simulate cooperative scenario payout. One of the groups (GColl-3) really did so right after the game; while it is probable that the GColl-1 group did so as well, we cannot be certain as in this case the rewards were handed out off the recording. This shows that these GColl groups strongly preferred the cooperative scenario, even if they were not able to reach it by coordinated game-play[3].

SVE groups took a different approach: very short-term plans (i.e., for the current round only) are most common, with more sophisticated strategies appearing only

[3] Only one SVE group (SVE-6) had a similar idea suggested by a participant during gameplay, but was dismissed immediately. Actually, it was understood as a very good joke by the others: "<laughing> you mean that I'll get the two chocolates for being the winner, and get even more from you? Yeah, I'd definitely take that."

	FTF	GColl	SVE
Strategy accepted	98%	79%	44%
Strategy then kept	79%	61%	39%

Table 1 Percentages of rounds where a common strategy was accepted; the second row shows how many of these agreements were then actually kept.

late into the game, if ever. In an example of this very narrow-sighted planning, members of groups SVE-1 and SVE-4 agree on several short term plans from the 8th and 5th round, with both groups ending the game in the 10th round due to heavy illegal mining that dries up the river. Members of these groups are very surprised at first, but understand the situation soon with exclamations as "*...I knew we forgot about something!*". Additionally, there are two SVE groups that never reach any agreement during the whole game.

There were differences among the three environments also in the number of rounds where an agreement was accepted/kept. Table 1 provides percentages of rounds where (i) any joint strategy was agreed upon by the group; (ii) and how often were such agreements kept. Again, SVE and FTF groups are strikingly different from each other, with GColl groups somewhere between the two extremes.

Tendency to Collaborate

Groups using different communication environments also differed in how they valued reaching cooperative goal. In particular, FTF groups strongly preferred the cooperative scenario, similarly to many groups in GColl condition. Most SVE groups preferred individualistic gameplay.

In all *face-to-face groups*, the discussion immediately focused on way in which the cooperative scenario could be reached with more-or-less whole group joining in to suggest various strategies. This means that all face-to-face groups implicitly chose the cooperative goal as the preferred scenario, although this was not suggested by the game rules in any way. Three *GColl groups* exhibited the same implicit preference for cooperative play as the face-to-face groups (and these were actually the three GColl groups to reach the cooperative scenario). Another two GColl groups agreed to redistribute the rewards after the game themselves, as they were not able to coordinate well enough to reach the cooperative scenario in the game but wanted to at least simulate cooperative outcome. The remaining two GColl groups also preferred collaborative play, but had problems with some of the participants defecting. *SVE groups* exhibited a much different pattern: except for one group, SVE-5, remaining groups either did not talk about cooperative play at all (three groups), or had to discuss it explicitly with several participants arguing and persuading the others to aim for the cooperative win (three groups). Out of these three groups, only one has eventually accepted the arguments and tried to play cooperatively.

Group dynamics

Many participants interacted differently with collocated vs. remote colleagues. This was mainly common in the majority of SVE groups (substantial effects in five out of seven groups). Almost no such signs appeared in GColl groups, with the exception of GColl-3; and even this particular group showed very mild effects when compared to most of the SVE groups.

For example, in the following exchange, the SVE-3 group is waiting for someone to click on their "Ready" button to continue the game (A/B represent the sites, numbers distinguish players at a site):

A1: (*to the screen*) Uhh, this takes a bit long, right?
B1: Yeah, everything is still shadowy.
A1: (*turning to a collocated player, quietly*) What did she say?
A2: (*quietly, turned to A1*) Don't know, I didn't understand either. (*turning to the screen, speaking loudly*) Hey, what did you say?

Two effects common for many SVE groups are visible in the transcript. The first is the tendency to consult just the collocated rather than all players in the case of a problem. Additionally, many players tended to speak slightly louder than normal when addressing the remote participants, but very softly when interacting with collocated ones. As these effects did not appear in GColl environment, where the very same audio setup was used, this is likely to be connected to the influence of the SVE environment, and not just technical difficulties. The second are moments when members in both sub-groups talked in parallel, each about a different topic, and each effectively ignoring completely what goes on at the remote site. Often, one of the groups started discussing a topic first, and the second site focused on something else after a while. As such, these effects cannot be attributed only to turn-taking problems commonly associated with video-mediated communication.

Majority of the SVE groups also exhibited strong *in-group/out-group effects* at each site; for example, the following conversation occurred very shortly into the SVE-6 game:

(*site B talking quietly on how they could strategize without allowing the other site to see/hear it*)
B1: [. . .] but if we show it on the screen, they can't see that, can they?
A1: (*talking to collocated colleagues*) So, we are split into 'us' and 'them' (*gesturing towards the screen*), right?
<everyone laughs>
B1: Like, we should play against each other?
(*A1 and B2 speaking over each other*)
B2: Yep, lets choose the safe way.
A1: Well, I guess it's the technology's fault. . . .

Similar examples of the collocated sub-groups understanding themselves as "us" and the others as an out-group, though not always so pronounced, appeared also in most of the other SVE groups. This was pointed out by the participants themselves during focus group sessions (done with SVE-5, SVE-6 and SVE-7); interestingly, even the two most successful SVE groups, SVE-5 and SVE-7, report the same problem. For example:

	FTF	GColl	SVE
Individual (e.g., "I")	28%	37%	50%
Group-related (e.g., "we")	72%	63%	50%

Table 2 Average percentage of individual/group-related pronouns

(*SVE-5 focus group*)
P1: I felt like we were separated [by the environment] into two teams...
P2: <*agrees*>
P1: I mean, even if it wasn't part of the game, we played as two teams ...
P3: (*interrupts*) yeah, we always thought that the problem is on their side, that it must be someone from them [who kept defecting].

Seeing such strong differences in group dynamics between SVE and GColl/FTF groups, we analysed usage of individual and group related pronouns such as "I" or "we". Prior literature shows how usage of these pronouns can reflect whether or not individuals consider themselves as part of a group [17], implicating cooperative (first-person plural pronouns such as we, us, and our) vs. competitive play (first- and second-person singular pronouns e.g., I, me, my, you, your). Returning to the video-recordings, we counted the ratio of these two types of pronouns individually for every group. Averages for each communication channel are shown in Table 2. While not conclusive, these percentages further illustrate the observed differences in group dynamics.

Summary of gameplay analysis

In a typical *face-to-face* session, the Goldminers game was played cooperatively with a lot of discussion on what is the best strategy and effective cooperation. While there might be some rounds where one or more participants do not follow the group strategy, these are not common. Face-to-face group typically reach the cooperative end-game condition. On the contrary, strategy related discussions are diminished in most *SVE groups*, with the majority of groups playing without a common plan of action for most of the time. Cooperative play, if present at all, needs to be usually explicitly discussed and argued for by the participants. Even if accepted by the group, many participants often do not comply (either by "staying on the safe side" due to a low group trust, or by actively abusing the trust of others). *GColl groups* prefer cooperative play much more often than in SVE and the level of strategy oriented discussions is very similar to that of face-to-face. However, some groups exhibited problems with defecting members or the inability to reach effective cooperative strategies (e.g., they start the discussion too late, or do actions without considering the long term effects).

Overall, the used communication environment had strong effects on participants' behaviour: GColl and FTF groups behaved similarly and shared the cooperative goal approach, but GColl groups were sometimes not able to coordinate well enough to reach it. SVE groups present radically different patterns of behaviour, with emphasis on individual play.

5 Discussion

We have compared three communication environments (face-to-face, GColl and standard videoconferencing (SVE)), analysing interaction during a social dilemma game. The game was played by groups of six strangers, each using a particular environment. Qualitative analysis of gameplay shows that interaction in groups using GColl was, in comparison to SVE, much closer to face-to-face discussions in terms of the tendency to cooperate, the amount of strategy oriented discussion, and the ability to reach a cooperative outcome scenario.

So what is it that makes the GColl environment more like face-to-face than another video-mediated communication system? Contrary to our expectations, participants did not make use of the gaze awareness functionality offered by GColl so enhanced gaze awareness cannot explain observed differences in behaviour.

One explanation, supported by our analysis of communication differences between local and remote participants, suggests that *group identity* developed differently in the SVE conditions than in the GColl and face-to-face conditions. Participants in the SVE condition used behavior that indicated they perceived the other participants as belonging to one of two groups - either a local group or a remote group. Moreover, their use of significantly more personal pronouns indicates a more individualistic approach to the game. In both the face-to-face and GColl conditions, we do not see evidence that the participants made a similar grouping.

As all other aspects were held constant, differences between GColl and SVE interfaces likely played a key role in shaping the perception of group identity. In SVE, only the remote participants are shown in a single video window which is shared by everyone at the site. A GColl user sees any other participant (i) in the same place (on her personal display); (ii) in an individual videostream. This means that, for any GColl player, all others are represented in the same virtual space. When analyzing the videorecordings, we found that most GColl users actually preferred to use the common virtual space (i.e., face their display) even when reacting to a remark by a collocated player. On the contrary, SVE users were forced to choose between looking at the remote, or collocated players at all times. We believe that this difference in how video streams were presented contributed to the GColl users' tendency to consider all players as a single group and to create a shared group identity (which is what happened naturally in all FTF groups), while the SVE players perceived two groups (local and remote).

Further supporting this explanation, the observed changes in behaviour are consistent with prior work on the effects of group identity on social dilemma games. In one study, shared group identity helped transform participant's understanding of a Prisoner's Dilemma task (where a "successful defection" is the most effective outcome) into an Assurance game that favors cooperation; and playing against a member of an antagonistic group (e.g., an out-group) diminished the tendency to collaborate [8]. Similarly, Bos et. al. [6] show how groups with strong group identity bonds (e.g., fraternity members) played more cooperatively in the Daytrader social dilemma task. Shared identity in FTF and GColl groups might be therefore the key factor in their preference for cooperative interaction; whereas the perception of two

distinct groups in the SVE condition may have contributed to participants taking a more adversarial approach to game play.

Future Work

Qualitative analysis shows substantial differences among the behaviour of groups in FTF, GColl and SVE, suggesting that differences in group identity were one of the key aspects. While effects of group identity on collaboration in face-to-face are already known, our observations suggest that differences in videoconferencing interface design can shape and/or change it. This opens interesting directions for further work, but also suggests that group identity might have played an important role in other settings. For example, the less effective seating conditions in [18], where collocated participants were seated side-by-side, might have induced stronger in-group behaviour, similarly to the SVE condition in this chapter.

We identified a combination of two design aspects present in GColl that were likely to affect the observed differences in behaviour. We argue how this combination of personal displays showing individualized videostreams from each participant (instead of a shared videostream depicting members from remote site), could have facilitated development of shared group identity. Further studies are needed to disentangle this combination and understand in detail how individual factors contribute to the observed effects. Additionally, it is not yet clear if and how these effects transfer into settings where the users know each other well, such as long term work-teams or family interactions.

6 Conclusion

This chapter reported on how group cooperation and collaboration patterns differed when groups of six discussed a task face-to-face, over a novel desktop videoconferencing design called GColl, or a commodity videoconferencing. Results show that groups interacting over GColl exhibit substantially lower in-/out-group effects when compared to commodity videoconferencing, and preferred collaborative over individual interaction similarly to face-to-face groups. The gaze awareness properties of GColl were not responsible for the observed changes in behavior. We argue instead, that the decisive effect is most likely based on the combination of having one display for, and a videostream of, each participant. We also suggest that the observed effects stem from differences in how group identity developed in groups using particular communication environment, and how the design differences contributed to this effect.

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