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ORIGINAL ARTICLE

Presence in the age of social networks: augmenting mediated environments with feedback on group activity

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Abstract The present study aimed at increasing behavioral engagement in groups of networked people by providing feedback on the group activity. Each participant logged into an on-line virtual environment for four subsequent treasure-hunting sessions along with other nine players. During the game, all players communicated dyadically through textual chats, and searched for the treasures in the virtual environment. In two conditions, the participants received a visual feedback depicting the communication activity with the group based on social network analysis indices (i.e. 'centrality' or 'reciprocity'). Feedback was not provided in the third condition. The underlying assumption was that if the group activity becomes more visible to the individual user through the feedback, then the behavioral engagement with the group increases. The resulting behavioral engagement was measured with two techniques, one based on the amount of messages exchanged and one based on self-reported measures. The results show that feedback improved the exchange of messages with respect to the control condition and that this effect was only partially captured by self-reported measures.

Keywords Social network analysis · Feedback · Social presence · Behavioral engagement · Multiplayer game · Augmented communication

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1 Social presence as behavioral engagement

Social presence, namely the "sense of being together with another" (Biocca et al. 2003, p. 456) has been studied in fields such as Communication and Human–Computer Interaction along with the technical solutions supporting it (reviewed by Biocca et al 2003; Schroeder 2006). The concept of social presence is typically applied to those cases in which the experience of being in the presence of another human being is mediated by a technology (e.g. through information and communication technologies; Licoppe and Smoreda 2006) or involves actors that are not human (e.g. computers or media characters; Reeves and Nass 1996). The possibility of experiencing a social presence in a mediated setting and with virtual humans represents not only a success criterion for telecommunication technologies allowing people to feel connected at a distance (see Castro and Gonzalez 2008; Spagnolli and Gamberini 2007) but also raises several issues, including ethic ones (Brahnam 2009; De Angeli 2009).

Biocca et al. (2003) have identified three broad dimensions in the social presence literature. The first is co-presence, a dimension that consists of purely acknowledging or being aware of the presence of another person in the same medium, also referred to as co-location. The second is the psychological involvement with the other, which implies an awareness of specific psychological attributes and implications related to co-location, and depending on receiving cues that nurture this involvement (Short et al. 1976). The third dimension, behavioral engagement, implies that interacting with other people defines the subjects' sense of social presence: two people feel each other's presence in a medium to the extent to which they can engage in some form of interaction. The way in which we would like to address behavioral

engagement is by treating it not as belonging to the realm of the individual 'feelings' but as an observable achievement emerging from the actors' social relationships; in other words, as a way of 'being socially present' instead of 'feeling socially present'. From this perspective, social presence is not addressed as an intimate phenomenon but as a relational, socially generated one. This dimension might not necessarily have a counterpart in terms of 'feelings' or 'perceptions', but it has pragmatic implications since it concerns how social presence is displayed by an actor and received by the interactants. It then has to do with the extent to which the actor is consequential on the social scenery.

In fact, recognizing the way to act on a social medium is not always straightforward, especially if other people in that medium are numerous. In computer supported social networks (Wellman 2001),[1] for instance, social presence derives not only from 'one-to-one' relationships but also from the relationship with the group; yet, individual members engage mostly in single interactions and lose sight of the overall dynamics of the social aggregate of which they are part. The next challenge in social presence research and applications is to enable the individuals to perceive this larger social aggregate, in order not just to 'feel' present in it but also to achieve an actual, rich behavioral engagement with it. Presence and social presence have already started to be elaborated theoretically (Zahoric and Jenison 1998; Spagnolli and Gamberini 2005; Spagnolli et al. 2008), and investigated qualitatively as pragmatic phenomena (e.g. Licoppe and Smoreda 2006; Arminen 2008). Here, we would like to focus on the possibility to increase the behavioral engagement at the group level and to reflect on the way to measure this increase.

We tried to face this challenge in the study described here, which is part of a larger project called PASION.[2] The strategy adopted to increase behavioral engagement was to make apparent the relationship between the user's action and the actions performed by all users, in order to make more visible—and then viable—the interdependence between them. The information provided was based on social network analysis (SNA) indices (Wasserman and Faust 1994), which can be obtained from automatically collected events,[3] such as chats (Paolillo 2001), blogs (Herring et al. 2005), and emails (Adamic and Adar 2005). These indices are calculated from the full set of relations between actors in a network; therefore, they are able to connect phenomena that are in sight of a single individual (e.g. contacting somebody) with phenomena pertaining to the whole group (e.g. the degree of reciprocity in the network of contacts). The individual action is projected on a larger scenario, the group, but remains the key to intervene upon it.

The value of this study then consists of providing some insights into a dimension of social presence that has not attracted much attention so far, behavioral engagement, and into the way to increase it at the group level. In addition, two methods to measure behavioral engagement are considered; one is based on the direct recording of the users' activity, and is considered to be more coherent with the emphasis on a dimension of social presence that directly refers to the interdependence between users' actions. The other method is based on self-reports. The study then contributes to understanding how to increase the behavioral engagement via feedback provision, and which measurement technique is more sensitive to capture this increase. The first section of this paper describes the previous findings from our own and other research, and concludes with the hypotheses of the study. The second section presents the experimental setting and design, and the third section illustrates the results. The difference between the two methods for measuring the feedback effectiveness is discussed in the conclusions.

1.1 Feedback on mediated activity

Making the interdependence between the individual and the group activity visible means to provide the user with a specific, group level feedback of his/her individual actions. Several theoretical models such as control theory (Carver and Scheier 1981), goal-setting theory (Locke and Latham 1990), and social learning theory (Bandura 1978) have investigated the motivating effect of receiving information about the consequences of own actions. Kluger and DeNisi (1996) carried out a meta-analysis of 131 studies on feedback intervention. They focused on the effect of feedback on performance and suggest that feedback works by drawing user's attention to one of three levels: task-motivation, task-learning, and meta-task (self). Task-motivation level

[1] In general terms, social networks can be defined as social aggregates composed by people carrying out activities within a certain social context (a context comprising other people); the relations established among actors (Wasserman and Faust 1994; Martino and Spoto 2006) define such networks. Authors further distinguish between kinds of social networks. For instance, Wellman (2001) differentiates "groups" from "community networks," the former characterized by being tightly bounded, densely knit, and composed by a limited set of people, the latter scarcely knit, composed by a high number of people and without precise boundaries.

[2] The PASION project aims at adding cues to a communication environment in order to enhance the users' social presence in the group (PASION, Psychologically Augmented Social Interaction Over Networks, reference number 27654 PASION, EU IST program, see Brugnoli et al. 2007).

[3] SNA based on this kind of data is often referred to as dynamic network analysis, see McCarley (2003), Kossinets and Watts (2006), and Bender-deMoll and McFarland (2006).

refers to the focal task at hand, the meta-task level links "the focal task with higher order goals (…) such as attention to the self, affect, and possibly framing effects" (p. 262), and the task-learning level regards the details of the focal task. When both goal and feedback are clear, optimal usage of feedback information to orient behavior occurs if it is processed at the task-motivation level, where the user is trying to find a way to fill the gap between the feedback value and the goal value. Therefore, a feedback on activity, such as the one planned in our augmentation strategy, has the highest motivational potential.

In the field of computer-mediated communication, the provision of activity feedback has been explored with good results. DiMicco et al. (2007) used a shared display during a decision-making task to illustrate users' participation rates, and to indicate over- and under-participators. Consequently, users' participation rates and information sharing changed in connection to the evaluation implicit in the feedback. Zumbach et al. (2005) proposed a problem-solving task supported by a html-based collaborative system, and implemented feedback based on explicit evaluations of users' behaviors. A trained human observer detected every episode of collaboration and displayed a reinforcement message on the participants' monitors. The highest amount of collaborative events was detected in the condition with distributed resources (another variable manipulated in the study) and with feedback. Both studies measured the aspects of group performance addressed by the feedback, e.g., collaboration, and found that they were affected by feedback provision.

In a study using SNA feedback, Gamberini et al. (2007) observed people playing a short online game. The study rationale was to analyze if the feedback effect depended on the mere provision of information, regardless of its quality, or if its quality mattered in producing an effect. The study found that the feedback containing false information (not reflecting the actual status of the relations within the group) had no effect on users' communication behavior. If feedback was correct, its provision increased participants' communication activity. In other words, providing a feedback that connected the users' actions with the activity of the whole group increased the behavioral engagement of the individuals with the group, and did so by virtue of the information contained in the feedback, not as a mere effect of the provision of some feedback.

With respect to this first study, the one described in this paper does not focus on false feedback but on the detailed effects of specific types of feedback. Participants in the previous study received mixed feedback based on both reciprocity and centrality; therefore, it was not possible to appreciate the effectiveness of each specific feedback type. In the study presented here, each group received only one feedback type (or no feedback). Moreover in the previous study, the behavior was observed in two sessions, without the possibility of studying the stability of the feedback effect; in the current study, players meet for four subsequent game sessions. The number of participants in each group is also raised from eight to ten in order to increase the range of possible values within a certain interval of the selected SNA index, thus making the index more able to discriminate the position of different participants. Finally, feedback effectiveness in this new study is evaluated by measuring the communication activity and by using a questionnaire, in order to accompany the analysis of automatically collected actions—more consonant with the nature of the dimension under investigation—with a more traditional methodology.

2 Method

2.1 Mediated environment and task

The mediated environment used in the study (the same used in Gamberini et al. 2007) was an on-line multiplayer game based on an open source, cooperative multiplayer graphical role playing game called 'Crossfire' (http://crossfire.real-time.com/). Using a game was preferred because of the increasing general interest in and attractiveness of games, and because of the need to use several sessions to study the stability of the feedback effect.

The task was a treasure hunt supported. Several goblets were hidden in the game environment, and information about the location of these goblets was provided through signs located in the different cities constituting the environment. From a bird's eye-view, each participant could see his/her avatar in the virtual environment, as well as any other participants' avatar wandering nearby. By pressing specific keys, the player could move the avatar around and perform some specific actions (picking up objects, reading signs). Participants were instructed that their team goal was to find as many goblets as possible in a limited amount of time (20 min), and that they could communicate with the other players, who were connected one-to-one via Skype® textual chats (http://www.skype.com) (see Fig. 1). Each player could only have a limited access to the virtual world at any given moment, so being informed of what was going on in other areas of the world made the quest more efficient. This information could be obtained by communicating with other players. Therefore, players could choose whether to concentrate on an exclusive exploration of the environment in search for cues and treasures, or whether to move this quest to a group level by exchanging information with other participants. By using the chat to communicate during the game, the players displayed their behavioral engagement with the group.

Fig. 1 Crossfire client and Skype displayed on the monitor during one game session

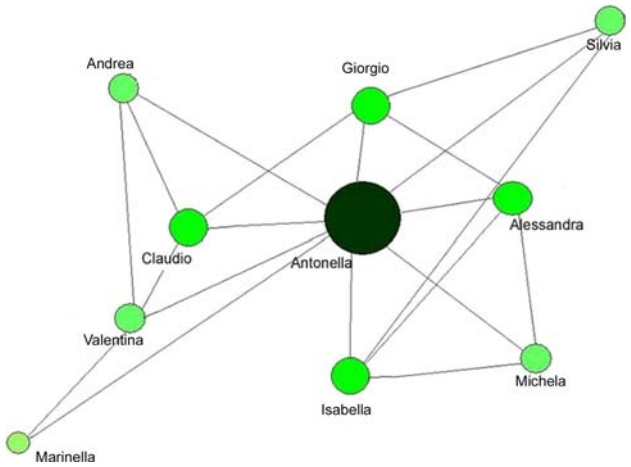

Fig. 2 An example of the centrality feedback visualization

2.2 Feedback

Two kinds of feedback, namely centrality and reciprocity, were used in the study based on different SNA indices of group activity.

"Centrality" is a structural attribute of a social actor within a network, consisting of his/her position and prominence with respect to the other actors. This attribute can be captured by degree centrality, the most intuitive centrality index. In terms of graph theory, the degree centrality of a node represents the number of other points adjacent to it. In social terms, it represents the number of interactions between an individual and other members of the group. Freeman (1979) suggests that degree centrality can represent a measure of the visibility that a social actor has in a network, or her/his ability to share information with others. In our study, if at least one message was exchanged between two participants, then a link among them was built. The higher the number of links connecting each team member to other members, the higher his/her centrality score. In order to calculate degree centrality, we measured, in each game session and in each couple of participants, if there was at least one exchange of messages. If this was the case, then we considered that a link existed between the couple of participants. A participant's degree centrality was calculated as the ratio between the number of other participants to which one is linked and the maximum number of links any participant can have. The value ranged from 0 (i.e. the participant had no link at all) to 1 (i.e. the participant was linked to all the other participants in the team).

The actual feedback consisted of a network representation, a visualization of the centrality values of all teammembers (Fig. 2): nodes with a higher centrality score had a more central position in the visualization, a wider diameter, and a darker tone of green. In Fig. 2, for instance, "Antonella" is the most central participant.

The second kind of feedback, based on "reciprocity," considered not only the number but also the direction of the relations. This is possible when ties between actors are bi-directional (Katz and Powell 1955), as when a person can be either the sender or the receiver of a message. Reciprocity was calculated here as the ratio between the number of reciprocated links and the number of the overall links each participant established or was involved in (Borgatti et al. 2001). Its value ranged from 0 (i.e. no connection with other participants was symmetrical) to 1 (i.e. all connections with the other participants were symmetrical). A link between actors was established when a communication event, called "thread starting request" (TSR), was sent from one participant to another.[4] More specifically, threads are temporally bounded sequences of contributions on a single topic (Yates et al. 2002), and TSR are the messages that are sent after a period of silence and can start a new thread since they do not belong to a previous one. In the chat below, for instance, a pair of players exchanged messages in two subsequent threads separated by 4 min of "silence." The first message in each thread is the TSR (italics).

(From Andrea–Michele, group 9, translated in English from Italian)

[16.39.34] Andrea: I found another goblet in the temple in the north city

[16.39.49] Michele: I found one in the south city

(pause)

[16.43.20] Michele: where are you?

[16.43.39] Andrea: north

[4] This is a measure of reciprocity at the level of thread, not at the level of each single message; it measures the willingness to communicate with the other. Identifying that a certain message is responded would require a deeper qualitative analysis. This work could not be carried out in the short pause between game sessions when reciprocity index was calculated and the visual feedback was built.

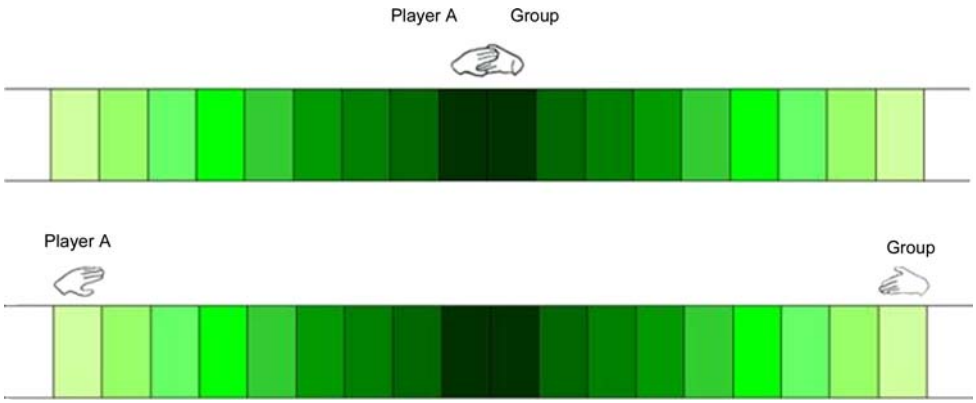

Fig. 3 A representation of feedback based on centrality measure; the one above corresponds to a situation where the participant had a low reciprocity value, while the one below corresponds to a situation in which the participant achieved the maximum level of reciprocity

In this chat, the initiative to start an exchange with the other person was taken by both players during the game. If at least one TSR was exchanged between two players during the game, like in the example, then their link was symmetrical: they both showed the willingness to communicate with the other at some point (regardless of the fact that those TSRs developed into longer conversations). Reciprocity values ranged from 0 when every link was asymmetrical to 1 when every link was symmetrical. The feedback consisted of a visualization like the one in Fig. 3: two hands join if reciprocity value is 1, or are far apart in the opposite case.[5] This representation derives from the idea that reciprocity is connected to cooperation (Mui et al. 2002), which can be easily associated with holding hands.

All feedback visualizations were accompanied by a brief written description.

2.3 Experimental design

Participants were 120 students at the University of Padova who volunteered to take part in the study (age: $M = 23.66$, $SD = 4.13$). After considering their availability (the experiment took about 3 h, thus participants' schedules needed to be considered when composing groups), participants were randomly assigned to 12 groups, each consisting of ten participants.

Feedback varied across subjects and had three levels. Four groups in the first condition received a feedback displaying the centrality value ("Centrality"), four groups belonging to the second condition received a feedback on reciprocity ("Reciprocity"), and four groups in the third condition received no feedback ("Control"). Each condition consisted of 40 participants, four groups of ten.

The members of a group met for four consecutive sessions within the same day. Therefore, session number varied between subjects and had four levels. The geography of the virtual world changed in each session. Beginning with the second session, feedback was calculated during the pause between sessions and was given to participants before resuming the game. This choice was supported by the literature, since Ilgen et al. (1979) reported that feedback works better when it is presented close to the task that it is meant to affect, and when it is associated with the original task. Murrel (1983) and Kerr et al. (2005) found that feedback does not need to be provided immediately after a performance, but instead, when a subsequent activity needs it.

2.4 Procedure

Participants met in the same computer room (see Fig. 4), read and signed an informed consent form, logged in the

Fig. 4 Participants are sitting in the same room, but are not allowed to talk. Three experimenters ensure the correct development of each game session

[5] The indices can be represented in several ways. The most intuitive is probably through connecting dots and lines (see Heer and Boyd 2005) as in Morris's Social Network display (2005) aimed at improving elderly people's social activity. This should not be considered as the only option. The social dimensions that emerged from the data extracted (e.g. the "popularity display" of Technorati, http://www.technorati.com) can be represented in indefinite number of ways, with the information about group structure and individual properties always remaining incorporated in the value of the index and in the properties of the representation (see Freeman 2000).

Skype® program, and were given the game instructions. Participants learned and became comfortable using game controls from a tutorial, which was at least 10 min long. After the tutorial, they were instructed that their only aim was to find as many hidden objects (i.e. goblets) as possible by using whatever kind of strategy they preferred. They were also told that they could communicate only via dyadic chat. Their activity was recorded on screen, and two members of the research staff remained in the room with them all the time.

Each gaming session lasted 20 min with an interval of 25 min between them. Before the second, third, and fourth session, participants, in the feedback conditions, were given feedback on their communication activity in the previous session.

They were told that the feedback represented their previous communication activity. The feedback was displayed on each individual monitor. After feedback presentation, they were requested to close the feedback window, and start another session.

At the end of the fourth experimental session, participants were asked to fill out a questionnaire.

2.5 Data

The data collected included the automatic log of the chats, and a questionnaire.

The chats were used to measure the number of message sent by each player, and then to assess the behavioral engagement with the group. The larger the number of messages sent by one participant, the more intense his/her behavioral engagement.

The questionnaire investigated two main aspects: the orientation to the group during the game, and the perceived quality of the feedback. The orientation to the group was investigated through items on co-presence, group belongingness, behavioral engagement, group awareness (items 1, 2, 3, 4, 5, 6, 9, and 11), and on the communication strategies during the game (items 7, 8, 10, and 12) (Table 1). There were no items on psychological involvement since this dimension of social presence is addressed by another study in the same PASION project, aiming at augmenting the awareness of the emotional state of the people in the group (see Brugnoli et al. 2007).

These items were administered to all participants. Some of them were taken from other questionnaires and reformulated to be coherent with the activity performed by our participants (a game) or with the answer format provided in the rest of the items: Item 1 from Schroeder et al. (2001), Item 5 from Biocca, Harms and Gregg's "Networked Mind Questionnaire" (2001), Item 11 from Cross et al. (2002) and Items 13, 17, and 19 from DiMicco et al. (2004). The answers were measured on a 5-point Likert scale ranging from "Always" to "Never" across the first five items, and

Table 1 Items used in the questionnaire

1	Did you experience to be in the same game environment as your teammates?	Co-presence
2	Did you expect to meet your teammates while exploring the environment?	Co-presence
3	Did you feel that you and your teammates were collaborating to achieve the same goal?	Group awareness
4	Did you feel as a member of the team?	Belongingness
5	Did you feel that your teammates depended on your actions?	Behavioral engagement
6	I was aware of what was happening in the team	Group awareness
7	My main concern was to find the goblets	Communication strategy
8	I contacted the people I already knew	Communication strategy
9	I knew who in my team had more information	Group awareness
10	I tried to contact the highest number of teammates as possible	Communication strategy
11	I knew who was available to help me	Group awareness
12	I replied to my teammates only if I knew the answer	Communication strategy
13	I find the feedback useful	Feedback quality (usefulness)
14	I think that the feedback about my situation was accurate	Feedback quality (accuracy)
15	I think that the feedback about the team situation was accurate	Feedback quality (accuracy)
16	I think that the feedback gave me information that I could not have obtained otherwise	Feedback quality (usefulness)
17	I noticed that the feedback influenced the team	Feedback quality (effectiveness)
18	I thought about the feedback during the game	Feedback quality (effectiveness)
19	I noticed that the feedback influenced my behavior	Feedback quality (effectiveness)
20	I would have liked to have a constantly available and updated feedback	Feedback quality (frequency)

In the column on the right, the dimension measured by the item is reported. This English version is a translation of the Italian questionnaire administered to participants

from "I totally agree" to "I totally disagree" across the remaining items. The direction of the scales was balanced (scores increased from left to right in one-half of the items and from right to left in the other half).

In addition, participants in the feedback condition were asked a set of questions on the perceived quality of the feedback, namely its effectiveness (items 17, 18, and 19), usefulness (Items 13 and 16), accuracy (items 14 and 15), and frequency (item 20). Perceived accuracy, in particular, was reported to affect feedback efficacy (DiMicco et al. (2007)); thus, it was particularly important to evaluate.

2.6 Study hypotheses

Previous literature reports that feedback presentation is able to produce a change in user's behavior, especially on those dimensions that are directly addressed by the feedback (DiMicco et al. (2007)). In our specific case, and based on the results of Gamberini et al. (2007), we expected that feedback would increase the rate of messages exchanged by participants while accomplishing the task. This would measure behavioral engagement with the group because the task can be carried out also individually. Only by communicating, acquiring and providing information with the group through the chat, did participants show that they were carrying out the task in cooperation with other group members and that they were recognizing the reciprocal interdependence. Based on this premise, the first hypothesis was:

(HP1) *A higher number of messages are sent to other team members in the groups receiving feedback with respect to the groups in the control condition.*

In this study, participants met over a prolonged period within several game sessions. This allowed us to observe if any change in participants' activity remained stable after repeated feedback provisions. Kluger and DeNisi (1996) reported an increase in the feedback effectiveness due to the feedback frequency but not due to the effect of task novelty. To test this premise, the second hypothesis stated:

(Hp2) *The increase in communication activity observed after feedback provision is to be found in all game sessions.*

A third research goal was to investigate the contribution of self-reported techniques in measuring behavioral engagement and other dimensions of presence in the group. The hypotheses are listed below.

(Hp3) *Players report a higher orientation to the group in the feedback conditions.* In particular:

(HP3a) *The group experience is rated higher in the feedback conditions compared to the control condition.*

(HP3b) *Group-oriented communication is rated higher in the feedback conditions compared to the control condition.*

In addition, we assessed the players' evaluation of the feedback quality, without any specific hypothesis related to the effect of the different conditions, but with the purpose of refining the feedback in future studies. Quality consisted of perceived effectiveness, usefulness, accuracy, and frequency, which are deemed important for the success of a feedback intervention (Ilgen et al. 1979; DiMicco et al. 2007).

3 Results

Since all participants were nested within groups, we used multi level models (MLM) to assess the non-independency of scores of each one of them (Snijder and Bosker 1999; Kenny et al. 2002). The design consisted of time (i.e. session number) nested within participants, and participants nested within teams, so in total we had three different levels of analysis. The model was implemented using SPSS mixed procedure (Peugh and Enders 2005) with time and experimental condition as fixed effects. Before every analysis, we calculated intra class correlation (ICC) value for each effect, following the procedure suggested by Quenè and van der Bergh (2004). ICC values are reported in the text for every type of data examined.

3.1 Analysis of the communication activity

The evaluation of feedback effectiveness based on measurement of users' communication activity relied on the analysis of the number of messages sent by each participant.

The ICC was calculated considering the number of messages sent by each player. ICC value was equal to 0.27, a value sufficiently high to suggest the use of multilevel models (Hayes 2006; Southwell and Doyle 2004).

The interaction between the session number and the feedback condition was significant [$F(6, 218.168) = 3.266$, $p = 0.004$]. Significant main effect was also found for the feedback condition [$F(2, 9.050) = 8.810$, $p = 0.008$], while the main effect for the session number was not significant [$F(3, 218.168) = 2.517$, $p = 0.059$].

To analyze these results in more detail, Table 2 reports the post hoc comparisons[6] of estimated marginal means. They do not reveal any significant differences among conditions during the first session. This means that, as

[6] Post hoc analysis described in this section involves comparison of 95% confidence intervals for the estimated marginal mean score across conditions in each different session.

Table 2 Mean and 95% confidence interval indicating lower and upper bounds of mean messages exchanged for each condition within each session

Session number	Condition	Mean	95% confidence interval lower bound	95% confidence interval upper bound
1	Centrality	18.55	13.14	23.97
	Reciprocity	16.22	10.81	21.64
	Control	16.10	10.69	21.51
2	Centrality	24.53	18.69	30.36
	Reciprocity	24.18	18.34	30.01
	Control	10.93	5.09	16.76
3	Centrality	25.68	20.31	31.04
	Reciprocity	25.73	20.36	31.09
	Control	11.58	6.11	16.84
4	Centrality	24.43	18.95	29.90
	Reciprocity	18.13	12.65	23.60
	Control	10.28	4.80	15.75

shown in Fig. 5, the intensity of the communication activity at the beginning was similar in all groups. Starting with the second session, namely after the first opportunity of feedback provision, the communication activity in the feedback conditions increased with respect to the control condition. This difference was found in the third session as well, where groups in the reciprocity and centrality conditions kept on showing a significantly higher communication activity than groups in the control condition. During the fourth session, values for centrality feedback remained higher; however, no difference was found between reciprocity and control conditions.

This analysis confirms that centrality feedback is effective and maintains its effect over time. The differences found between conditions receiving the feedback and the control condition show that the increase in the communication activity is not a natural consequence of meeting several times with the same teammates, but an effect of the exposure to the feedback. Reciprocity feedback is effective, but tends to decrease after a certain number of sessions, equaling the initial level at the fourth session.

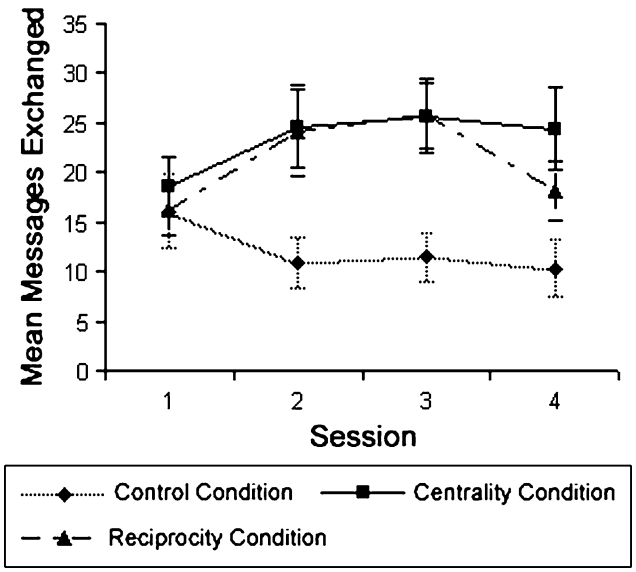

Fig. 5 The mean number of messages exchanged within a team across three experimental conditions and four sessions

3.2 Self-reported measures

Regarding the self-reported measures collected at the end of the fourth session, the results pertaining to group experience are presented first (items 1–12, Fig. 6) and those related to feedback quality, which was only evaluated by participants in the centrality and reciprocity conditions (items 13–20, Fig. 7) follow. We used multi level models (MLM) to assess the non-independency of scores of each participant while comparing the rates of each item across different conditions. The design contained participants nested within teams, so in total we had two different levels of analysis.

3.2.1 Group experience

The analysis showed no significant effects for the feedback conditions across items 1–6. Players in the feedback conditions did not declare different levels of co-presence (items 1 and 2), behavioral engagement (item 5), belongingness (item 4), or group awareness (items 3 and 6) compared to the users in the control condition. Significant differences, consistent with the feedback presented, were found for item 9 of group awareness reporting the players' awareness of specific characteristics of the group ("I knew who is the person who had more information in my team"), [$F(2,\ 116.00) = 6.198,\ p = 0.003$].[7] Centrality feedback

[7] ICC value was 0.49 for item 9. This value is sufficiently high to suggest the use of multilevel models.

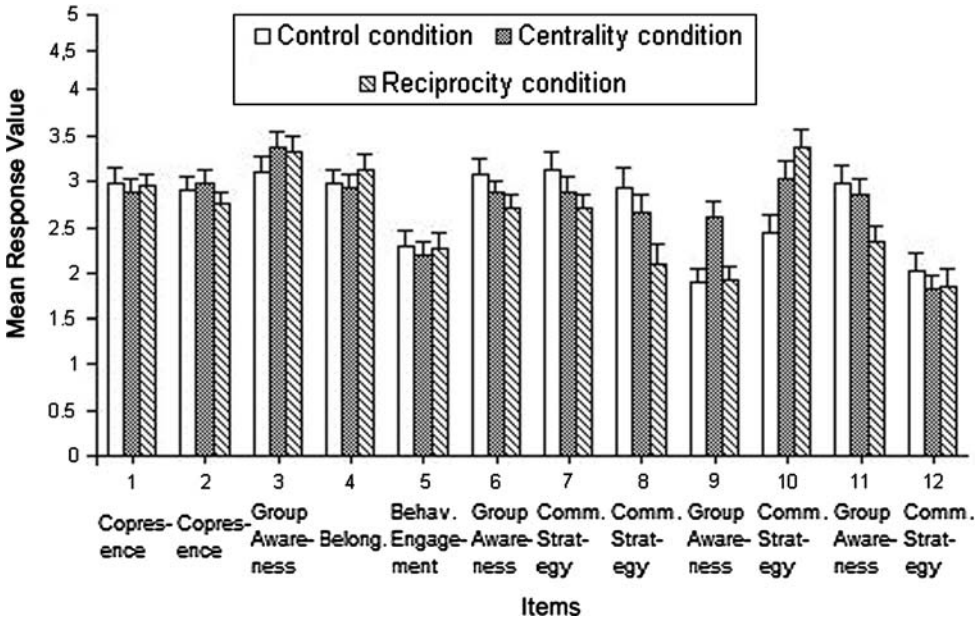

Fig. 6 *Mean and error bars* of the group experience items for the three conditions

seems to have provided better information in this item, since it showed a significantly higher value ($M = 2.60$, SD = 1.10) than with no feedback ($M = 1.90$, 0.97, LSD test, $p = 0.002$) or with reciprocity feedback ($M = 1.92$, SD = 0.94, LSD test, $p = 0.002$). This result was expected, because centrality feedback visually emphasizes the actor who has more exchanges in the group.

3.2.2 Group-oriented communication

Regarding the players' communication strategies during the game, reciprocity seemed to have provided the most effective information. Significant differences were found for two items inquiring about communication strategies, namely items 8 [$F(2, 117.00) = 4.182$, $p = 0.018$], and 10 [$F(2, 117.00) = 6.794$, $p = 0.002$)].[8] Item 8 ("I contacted people I knew") had significantly lower values in the reciprocity feedback condition ($M = 2.10$, SD = 1.30) compared to the control condition ($M = 2.93$, SD = 1.31, LSD test, $p = 0.005$), meaning that participants in this condition were less dependent on prior acquaintances (being students in the same university, some participants already knew each other) when deciding whom to contact to exchange information during the game. Item 10 ("I tried to contact as many people as I could") also showed significantly higher levels in reciprocity ($M = 3.38$, SD = 1.13) compared to control conditions ($M = 2.45$, SD = 1.15, LSD test, $p = 0.020$), thereby providing additional support to the finding that reciprocity feedback was able to promote exchanges between all players.

[8] ICC value is 0.33 for item 8, sufficiently high to suggest the use of multilevel models.

3.2.3 Perceived feedback quality

The second part of the questionnaire investigated the perceived feedback quality. It was administered only to the 80 participants in the two feedback conditions. The results are shown in Fig. 7. We were interested in the general rating, a positive, or a negative, obtained by the feedback, as well as in any differences between the two kinds of feedback.

General values of accuracy and usefulness were moderately positive, namely they were in the 'agreement' segment of the answer scale ranging from 1 (disagreement) to 5 (agreement).[9] When asked, in item 20, if they have wished a constantly available and updated feedback, answers were neutral (centrality condition: $M = 2.97$, SD = 1.16, reciprocity condition: $M = 2.85$, SD = 1.21). In the centrality condition, the values were higher on accuracy, i.e., items 14 [$F(1,78) = 18.70$, $p < 0.001$], and 15 [$F(1,78) = 20.62$, $p < 0.001$], and on one item about feedback usefulness, item 16 [$F(1,78) = 10.32$, $p = 0.002$].[10] Centrality feedback might have appeared as more accurate because it reported all participants' values (see Fig. 2); this interpretation is consistent with the answers obtained from participants in this condition about

[9] Item 13, centrality condition: M 3.33, DS 0.69, reciprocity condition: M 2.98, DS 1.05.

Item 14, centrality condition: M 3.76, DS 0.67, reciprocity condition: M 2.96, DS 0.96.

Item 15, centrality condition: M 3.8, DS 0.65, reciprocity condition: M 3.00, DS 0.91.

Item 16, centrality condition: M 3.66, DS 1.00, reciprocity condition: M 2.82, DS 1.28.

[10] ICC values were, respectively, 0.29 for item 14, 0.56 for item 15, 0.64 for item 16. All these values were sufficiently high to suggest the use of multilevel models.

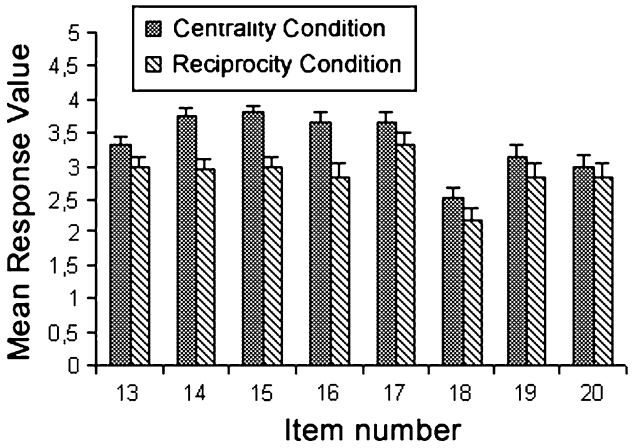

Fig. 7 *Mean and error bars* of the feedback quality items for the two feedback conditions

being aware of specific information (who had more information in the team), already discussed above.

Participants' own perception of feedback effect on the group and on their own activity (items 17[11] and 19[12] respectively) was moderately positive. When asked, in item 18, whether they thought about the feedback during the game, their position was neutral (centrality condition: $M = 2.53$, SD = 1.01, reciprocity condition: $M = 2.2$, SD = 1.16).

In conclusion, participants reported a difference in the feedback conditions when asked about their specific communication strategy, or awareness of specific information, but not when asked about general feelings toward the group. Feedback was rated positively, especially the centrality feedback, and its effectiveness was moderately evident to them.

4 Conclusions

The review of the social presence literature presented by Biocca et al. (2003) suggests that being and feeling socially present are two different dimensions. People are socially present in a mediated environment when they are interdependent on other people inhabiting the same environment. To enhance this dimension of social presence, the interaction and the mutual engagement must be increased. Alternatively, people feel socially present because they intensely feel the engagement with the other agents, and an intervention to increase this feeling must rely on cues that affect their emotional experience. The intervention in our study was meant to encourage the former, the behavioral engagement within the group, by making the overall structure of the relations within the group visible, and by connecting it with the activity controlled by the individual, i.e. sending messages. This allows the user to reorganize his/her communication strategy and affect the group structure.

The results confirm that behavioral engagement is one specific dimension of social presence that can be improved with feedback and must be captured with sensible measurement tools.

The feedback effectiveness—and then behavioral engagement—was evaluated with two techniques. One of them, the number of messages sent by participants, is fully consistent with the dimension of social presence addressed by the feedback. The results showed that the groups exposed to the feedback increased their communication activity significantly, differentiating themselves from groups that have a similar starting level of communication but are not provided with any feedback. Therefore, the first hypothesis of the study was confirmed.

The second hypothesis regarding the stability of the feedback effect was confirmed for centrality and partially for reciprocity. Centrality feedback promoted an increase in communication in all sessions, whereas reciprocity feedback increased the number of messages exchanged between the initial and the third sessions, but did not maintain this level during the final session. This latter result could depend on the fact that reciprocity feedback affects other aspects of the communication activity in addition to the overall number of messages sent, for instance the direction of the exchange. More specifically, reciprocity is a less spontaneous way of organizing communication, implying that a person bases the selection of the recipients on the symmetry established in his/her network up to that moment; therefore, it is more subject to fatigue, and then weakens in the fourth session.

The third hypothesis concerned the ability of self-reported techniques to discriminate between the feedback conditions and then to measure differences in behavioral engagement. On the bases of the results, this ability seems poor and limited to those items that related more directly to the practical aspects of the social presence in the group. More specifically, in some of the items related to group-oriented communication, self-reported measures discriminated between feedback conditions. Only with respect to these items and for participants in the reciprocity condition was Hypothesis 3b confirmed. Regarding the items on group experience, HP3a (the group experience was rated higher in the feedback conditions than in the control condition) was confirmed in the centrality condition and with respect to awareness of specific information regarding the

[11] Item 17: centrality condition: M 3.65, DS 0.95, reciprocity condition: M 3.33, DS 1.11.

[12] Item 19: centrality condition: M 3.15, DS 1.05, reciprocity condition: M 2.85, DS 1.27.

group information (i.e. knowing who has more information in the team). No increase was reported instead in the items that inquired directly about the reported feeling of social presence, group awareness, or behavioral engagement, and HP3a was not confirmed across these dimensions. This latter group of items did not focus on the pragmatic dimension of social presence addressed by the feedback, but on the feelings of social presence. In addition, these feelings were not directed to social activity, but to the social actor who carried out this activity (i.e. "the group"). The overall results of the questionnaire then suggest that being behaviorally engaged with the group and feeling present in the group are different dimensions. They also suggest that, in order to capture the former dimension, the most appropriate method seems to be the one based on the recording of the group activity and not on self-reports.

In conclusion, the feedback tested here proved to be a good candidate for inclusion in an augmented communication system in order to increase behavioral engagement in the group. It will augment this dimension of social presence in large groups, whose size could otherwise hamper the individuals' ability to grasp the interlaced network of activities. To increase the feeling of being present in a group, instead, other kinds of information could be more adequate, e.g. physiological measures or emotional state icons. This latter augmentation strategy is actually under investigation by other research groups in the PASION project.

The investigation possibilities opened by this study are vast. The current study represents the group situation from the perspective of the individual (e.g. centrality and reciprocity). Future research can investigate whether feedback representing the situation from the perspective of the group (e.g. centralization or cohesion) is as effective on behavioral engagement. It would also be interesting to systematically vary the features of the feedback visualization, from detailed representations of the group structure to synthetic overall group values, and assess their effectiveness (studies on the effectiveness of different representations of structural properties of networks were described for instance, by Ware et al. 2002). The goal would be to study which kind of group feedback is more able to embed the task-motivation level identified by Kluger and DeNisi (1996), where the individual is able to connect the quality of his/her own activity with the one depicted by the feedback and is motivated to adjust the former. Behavioral engagement in communication networks is also open to qualitative investigation, focusing on the communication practices enacted by users, which that spread across networks to constitute interlocked communities of practice (e.g. Holmes and Meyerhoff 1999). Finally, the 'increase' of behavioral engagement on a purely quantitative level should be accompanied by a reflection on the resources provided to users: feedback intervention can empower people but can also disempower them, to the point of shaping group activity for unilateral opportunistic reasons and against the benefit of the group (Borgatti and Molina 2005).

In conclusion, given the societal impact of networked environments, the ability to feel the presence of a large social aggregate has little sense if individuals are not motivated to engage actively with a social group. We believe that there is a need for more research in this underrepresented aspect of social presence since it would facilitate the exploitation of mediated networks for a more active and aware social participation.

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References

Adamic L, Adar E (2005) How to search a social network. Soc Netw 27:187–203

Arminen I (2008) Configuring presence in simulated and mobile contexts. In: Proceedings of the 11th annual inter workshop on presence. Available at: http://www.temple.edu/ispr/prev_conferences/proceedings/2008/arminen.pdf. Accessed 01 May 2009

Bandura A (1978) Social learning theory of aggression. J Comun 28:12–28

Bender-deMoll S, McFarland DA (2006) The art and science of dynamic network visualization. J Soc Struct 7. Available at: http://www.cmu.edu/joss/content/articles/volume7/deMollMcFarland. Accessed 01 May 2009

Biocca F, Harms C, Gregg J (2001) The networked minds measure of social presence: pilot test of the factor structure and concurrent validity. In: Proceedings of 4th annual workshop on presence

Biocca F, Harms C, Burgoon JK (2003) Towards a more robust theory and measure of social presence: review and suggested criteria. Presence 12:456–480

Borgatti SP, Everett MG, Freeman LC (2001) Ucinet for Windows: software for social network analysis. Analytic Technologies, Harvard, MA

Brahnam S (2009). Building character for artificial conversational agents: ethos, ethics, believability, and credibility. Psychnol J 7(1):9–47. Available at: www.psychnology.org. Accessed 01 May 2009

Brugnoli MC, Morabito F, Walker R, Davide F (2007) The PASION project: psychologically augmented social interaction over networks. Psychnol J 4:103–116

Carley KM (2003) Dynamic network analysis. In: Breiger R, Carley K, Pattison P (eds) Dynamic social network modeling and analysis: workshop summary and papers. National Research Council, Washington, DC, pp 133–145

Carver CS, Scheier MF (1981) Attention and self-regulation: a control theory to human behavior. Springer, New York

Castro LA, Gonzalez VM (2008) Being part of the life of one's hometown: strategies to support community connectedness. Psychnol J 6(1):61–82. Available via www.psychnology.org. Accessed 01 May 2009

Cross R, Parker A, Borgatti SP (2002) Making invisible work visible: using social network analysis to support strategic collaboration. Calif Manage Rev 44:25–46

De Angeli A (2009) Ethical implications of verbal disinhibition with conversational agents. Psychnol J 7(1):49–57. Available at: www.psychnology.org. Accessed 01 May 2009

DiMicco JM, Bender W et al (2007) Reactions to visual feedback tools. In: Proceedings of 2nd international conference on persuas technology

DiMicco JM, Pandolfo A, Bender W (2004) Influencing group participation with a shared display. In: Proceedings of ACM conference on computer-supported cooperative work (CSCW 2004)

Freeman LC (1979) Centrality in social network: conceptual clarification. Soc Netw 1:215–239

Freeman LC (2000) Visualizing social structure. J Soc Struct 1. Available at: http://www.cmu.edu/joss/content/articles/volume1/Freeman.html. Accessed 01 May 2009

Gamberini L, Martino F, Scarpetta F, Spoto A, Spagnolli A (2007) Unveiling the structure: effects of social feedback on communication activity in online multiplayer videogames. In: Schuler D (ed) Online communities and social computing, Springer, Heidelberg, pp 334–341

Hayes A (2006) A primer on multilevel modelling. Hum Comun Res 32:385–410

Heer J, Boyd D (2005) Vizster: visualizing online social networks. In: IEEE symposium on information visualization. Available at: http://www.danah.org/papers/InfoViz2005.pdf. Accessed 01 May 2009

Herring SC, Kouper I, Paolillo JC et al (2005) Conversations in the blogosphere: an analysis from the bottom up. In: Proceedings of 38th Hawaii international conference on system science

Holmes J, Meyerhoff M (1999) The community of practice: theories and methodologies in language and gender research. Lang Soc 28:173–183

Ilgen DR, Fisher C, Taylor MS (1979) Consequences of individual feedback on behavior in organizations. J Appl Psychol 64:349–371

Katz L, Powell JH (1955) Measurement of the tendency toward reciprocation of choice. Sociometry 19:403–409

Kenny DA, Mannetti L, Pierro A et al (2002) The statistical analysis of data from small groups. J Pers Soc Psychol 83:126–137

Kerr NL, Messe LA, Park ES, Sambolec EJ (2005) Identifiability, performance feedback and the kohler effect. Group Process Intergroup Rel 8:375–390

Kluger AN, DeNisi A (1996) The effects of feedback interventions on performance: a historical review, a meta-analysis, and a preliminary feedback intervention theory. Psychol Bull 119:254–284

Kossinets G, Watts DJ (2006) Empirical analysis of evolving social networks. Science 311:88–90

Licoppe C, Smoreda Z (2006) Rhythms and ties: towards a pragmatics of technologically-mediated sociability. In: Brynin KrautR, Kiesler S (eds) Domesticating information technologies. Oxford University Press, Oxford, pp 296–313

Locke EA, Latham GP (1990) A theory of goal setting and task performance. Prentice Hall, Englewood Cliffs, NJ

Martino F, Spoto A (2006) Social network analysis: a brief theoretical review and further perspective in the study of information technology. Psychnol J 4:53–86. Available at www.psychnology.org. Accessed 01 May 2009

Morris ME (2005) Social networks as health feedback displays. IEEE Internet Comp 9(5):29–37

Mui L, Mohtashemi M, Halberstadt A (2002) A computational model of trust and reputation. In: Proceedings of 35th Hawaii international conference on system science

Murrel S (1983) Computer communication system design affects group decision making. In: Proceedings of the ACM SIGCHI conference on human factors in computer systems

Paolillo JC (2001) Language variation on internet relay chat: a social network approach. J Socioling 5:180–213

Peugh JL, Enders CK (2005) Using the SPSS mixed procedure to fit cross-sectional and longitudinal multilevel models. Educ Psychol Meas 65:717–741

Quenè H, van der Bergh H (2004) On multi-level modelling of data from repeated measures design: a tutorial. Speech Commun 43:103–121

Reeves B, Nass C (1996) The media equation: how people treat computers, television, and new media like real people and places. CSLI Publications, Stanford, CA

Schroeder R (2006) Being together and the future of connected presence. Presence 14:438–454

Schroeder R, Steed A, Axelsson A-S et al (2001) Collaborating in networked immersive spaces: as good as being there together? Comp Graph 25:781–788

Short J, Williams E, Christie B (1976) The social psychology of telecommunications. Wiley, London

Snijder T, Bosker R (1999) Multilevel analysis. Sage Publications, London

Southwell B, Doyle K (2004) The good, the bad, or the ugly? A multilevel perspective on electronic game effects. Am Behav Sci 48:391–401

Spagnolli A, Gamberini L (2005) A place for presence. Understanding the human involvement in mediated interactive environments. Psychnol J 3:6–15. Available at: www.psychnology.org. Accessed 01 May 2009

Spagnolli A, Gamberini L (2007) Interacting via SMS: practices of social closeness and reciprocation. Br J Soc Psychol 46(2):343–364

Spagnolli A, Scarpetta F, Tona T, Bortolatto T (2008) Conversational practices and presence: how the communication structure exploits the affordances of the medium. Proc Presence 2008:107–116

Ware C, Purchase H, Colpoys L, McGill M (2002) Cognitive measurements of graph aesthetics. Inf Vis 1(2):103–110

Wasserman S, Faust K (1994) Social network analysis. Methods and applications. Cambridge University Press, Cambridge, MA

Wellman B (2001) Computer networks as social networks. Science 293:2031–2034

Yates J, Orlinowski WJ, Wörner SL (2002) Virtual organizing: using threads to coordinate distributed work. In: Proc of the 36th Hawaii international conference on system science. Available at: http://seeit.mit.edu/Publications/HICSS2003_Virtual_Organizing.pdf. Accessed 01 May 2009

Zahoric P, Jenison RL (1998) Presence and being in the world. Presence 7:78–89

Zumbach J, Schönemann J, Reimann P (2005) Analyzing and supporting collaboration in cooperative computer-mediated communication. In: Proceedings of the 2005 conference on computer supported for collaboration, pp 758–76