# "Your Team Cohesion is Low": A Systematic Study of the Effects of Social Network Feedback on Mediated Activity

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**Abstract.** Collaborative mediated environments compete to provide visitors with social feedback, whose actual effects on visitors' behavior is poorly known. This study considers feedback based on Social Network Analysis (SNA) and assesses whether this feedback is able to affect user activity in an online collaborative game. The results show that SNA feedback is able to modify group activity beyond a mere novelty effect, especially on the dimensions of the behavior covered by the feedback itself. The results also point to the possible role of task type in accounting for the feedback effect on behavior.

**Keywords:** Social Network Analysis, Social Feedback, Computer Mediated Communication, Online Collaborative Games.

## 1 Introduction

The availability of digital technologies to communicate and collaborate has continuously progressed over the last three decades [1]. A recent result of this development is social networking services implemented on websites and in other mediated environments, which turn users' network from a latent, hidden infrastructure into an explicit, visible social object with its own value. Models and algorithms, elaborated by Social Network Analysis (henceforth, SNA) [2],[1] are usually adopted to extract the structure and properties of a social network; several applications use them to make interactions visible or create social statistics [3], namely as a sort of feedback [4]; however, the effect of this information on user behaviors has seldom been evaluated (with the exception of a few studies; e.g., Morris [5]). The current study aimed to fill this gap by investigating, systematically, the effect of SNA feedback on specific dimensions of mediated activity.

[1] For instance, the popular blogging service Technorati provides information on the "popularity" of a blog by calculating the number of links connected to it.

A.A. Ozok and P. Zaphiris (Eds.): Online Communities, HCII 2011, LNCS 6778, pp. 172–181, 2011.

Previous studies using SNA-based feedback have found that they are effective in sustaining and increasing user activities [6,7], especially when information is perceived as correct and trustworthy [8]. The current study extends these results by adding two feedback types (density and centralization). These added SNA indices are at the group level (i.e., describing the status of the whole network with respect to a certain dimension) and literature has reported differences when feedback is administered at the group versus individual level [9,10]. Thus they are worth a specific investigation.

The first hypothesis served as a preliminarily check to determine whether the newly added conditions could trigger the same effect observed by Martino et al. [6], namely an increase in the number of messages exchanged in the group. The explanation for that effect was that feedback on communication made more relevant the interactional dimension of the activity and then encouraged participants to invest more in this dimension by increasing their behavioral engagement. The number of messages exchanged in the group was taken as an overall, generic measure of this mutual behavioral engagement.

***H1****: The provision of SNA feedback on communication increases the number of messages sent from every player to the other team members with respect to control groups with no feedback provision.*

The second hypothesis is related to the stability of this effect across subsequent activity sessions, discarding the possibility that the feedback effect is merely due to its novelty. In addition, Martino et al. [6] found that feedback, based on reciprocity, had less stable effects than did feedback based on centrality. As an explanation, in [6] it was hypothesized that some fatigue emerged from the previous session and made subtler aspects of communication (such as those needed in ensuring symmetry between all exchanges) more difficult to control. Thus, in the current study we tested if this explanation would hold true for group feedback regarding communication symmetry:

***H2****: Feedback density increases communication activity in all game sessions, whereas feedback on centralization has a smaller or no effect in the final game sessions.*

The third aspect considered was the specificity of the feedback effect because, in the literature, it has been assumed but not directly investigated. In fact, there are only a few studies that have systematically evaluated the effect of augmenting group-mediated interaction via the provision of some type of feedback about the communication activity [11,12,13]. These studies have tested the effectiveness of such feedback on the aspects of group processes covered by the feedback itself (which might increase or decrease according to user's position in the group), somehow presupposing that feedback worked by affecting the specific areas of behavior on which it provided information. In the current study, this assumption was tested directly, since effectiveness and stability were assessed on several dimensions of communication with respect to the specific information provided by the feedback.

***H3****: A specific dimension of communication is always affected by the feedback on that same dimension. More specifically, the value of degree centrality increases after*

*the provision of degree-centrality feedback; the value of reciprocity increases after provision of reciprocity feedback; the value of density increases after provision of density based feedback; the value of centralization increases after provision of centralization feedback.*

## 2 Method

Participants were grouped into teams that played an on-line treasure hunting game (based on the Crossfire platform) for four consecutive sessions. Participants communicated via dyadic chat (through Skype®[2]) and their message exchanges were logged and measured. Prior to each new game session, participants in the feedback conditions viewed an SNA index that measured a property of the communication activity of the group from the previous game session. Type of feedback varied between subjects and could cover Centrality, Reciprocity, Density, or Centralization; no feedback was provided in the Control Condition.

The two new feedback conditions added in the current study involved 80 voluntary participants with similar characteristics of [6] (age $M = 23.05$, $SD = 2.71$; 37 men, 43 women). They were recruited by asking university students met at the university premises; people who agreed to participate where then randomly assigned to the different teams. The overall design was composed by these new conditions in addition to the conditions of the previous study. In total, the design involved 200 participants (86 men and 114 women, age: $M = 23.66$, $SD = 4.14$) who were distributed among five between subjects feedback conditions. Each condition included four teams (40 participants).

### 2.1 Feedback

The types of feedback displayed are shown in Figure 1[3].

"Centrality" describes how extensively a social actor is involved in social relationships with other actors in the communication network [2]. In the current investigation, centrality was visualized as a network; nodes represented actors and lines represented the ties between actors. Nodes with a higher centrality occupied a more central position, had a wider diameter, and a darker tone of green (Figure 1a).

"Reciprocity" is the tendency of an actor to reciprocate the action of other actor and can be considered as a measure of cooperation [14]. The event in which this symmetry was measured was the initiation of a dyad communication exchange. This event was called "Thread Starting Request" (TSR), where threads were temporally

[2] We choose to use Skype because it is more intuitive than the communication system embedded into Crossfire. Some informal pilot sessions were conducted to determine whether participants could easily use these two programs together and no difficulty was observed (nor were any difficulties complained about during the actual experimental sessions). Only dyadic communication was allowed in order to make the recipient of the message and then the analysis of the ties in the network more straightforward (of course, participants were allowed to open more chats simultaneously to keep in touch with more than one teammate at a time).

[3] While all indices are mentioned in this paper with the name they have in SNA literature, in this study some were re-named with more intuitive labels to better convey their meaning to common users.

bounded sequences of messages on a single topic [6,15] and a TSR was a message that potentially started a new thread. Participants reciprocated if both individuals in a dyadic chat attempted to start a new thread of messages at some point during the session. The representation of this index (Figure 1b) consisted of a graduated scale; two hands were joined when reciprocity between a certain actor and the rest of the group was at a maximum and the hands were separated when there was no reciprocity.

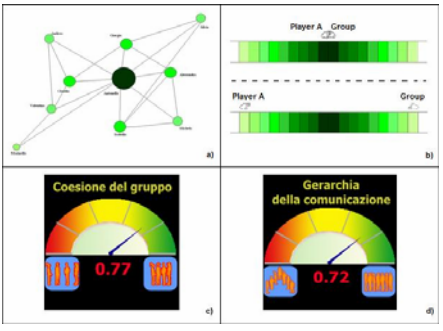


**Fig. 1.** Examples of the four types of feedback used in the various feedback conditions: (a) degree centrality, (b) reciprocity, (c) density, (d) and centralization

"Density" measures network cohesion [2]. The representation used in our study (Figure 1c) consisted of a graduated meter with an arrow pointing to the position on the meter that corresponded to the index value. "Centralization" measures the tendency of a network to be more or less centralized around a few actors [2]. The representation used in our study was similar to the one adopted for the density feedback, except for the two icons representing extreme values (Figure 1d). Formulas for calculating indices follow Wasserman & Faust [2], with the only exception of centralization (where the final value was achieved by subtracting the value obtained in the classic formula from 1, which maximized the index value when the network was decentralized). All index values varied from 0 to 1.

### 2.2 Task and Procedure

Each participant was represented by an avatar in a large team-shared virtual world. The world contained hidden goblets (the treasure), different locations participants were free to explore, clues to help to find the goblets, and virtual food to keep the avatars alive. Participants acted in the virtual environment using a mouse and keyboard. To present the activity as a cooperative task, participants were informed that the winner would be the team that found the most goblets for all sessions.

Participants who belonged to the same team met in a computer room. After signing an informed consent, participants received instructions on the game and played a 10-minute training session to familiarize themselves with the game and the controls. Each experimental session lasted 20 minutes with a 25-minute break in between sessions. Feedback was displayed on the participant's monitor at the beginning of

each new session for the feedback conditions; a standard explanation of the feedback visualization and the index value was provided to all participants; no evaluation was implied in the explanation that could encourage the achievement of a specific index value.

### 2.3 Data Collection and Analysis

The data collected were obtained from the chats that occurred during the game sessions. Of these data, the overall number of messages exchanged was calculated as well as Degree Centrality, Reciprocity, Density, and Centralization. The statistic procedure used to test the hypotheses varied according to the nature of the dependent variable; namely whether it measured data at the group or individual level. The former case applied to centralization and density and a mixed design ANOVA was performed, with Condition and Session as main factors. Individual indices included the number of messages, degree centrality, and reciprocity. For these measures, Multi Level Models (MLM) were adopted to account for the non-independency of scores for each individual in the group [16]. These models were implemented using SPSS Mixed Procedure [17], with Session and Condition as fixed effects and group belongingness as a random effect. Effect size was calculated using the *d* coefficient, as suggested by Williams et al [18]. Post-hoc analyses were conducted by comparing 95% confidence intervals[4] for the mean value of groups in each condition and along the four gaming sessions.

## 3 Results

### 3.1 Effect on the Number of Messages Exchanged

It was assumed that the number of messages exchanged in the group would measure the general feedback effect on communication activity. The results are illustrated in Figure 2. The analysis yielded significant results for the main effects of the factors

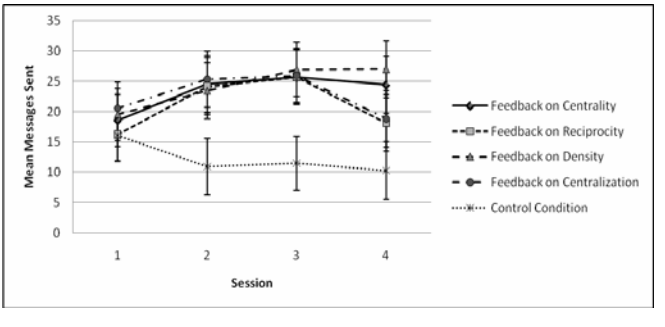


**Fig. 2.** Number of messages exchanged in each experimental condition in the four sessions of game. Error bars correspond to 95% Confidence Intervals.

[4] Confidence Intervals were calculated using SPSS EMMEANS procedure for MIXED MODELS (SPSS v. 16).

"Condition," F(4, 192.281) = 6.572, $p < .001$, $d = .49$ and "Session," F(3, 222.75) = 10.331, $p < .001$, $d = 0.47$ and for the interaction between Session and Condition, F(12, 222.775) = 3.673, $p < .001$, $d = .30$. During the first session, the comparisons of estimated marginal means did not reveal any significant differences among conditions. In the second and third sessions, namely after the feedback provision, fewer messages were exchanged in the control condition compared to the feedback conditions; feedback conditions did not significantly differ. In the fourth session, the number of messages remained higher in the centrality and density conditions; however, it did not differ from the control group in the centralization and reciprocity conditions.

### 3.2 Effects on Degree Centrality

Results for degree centrality are displayed in Figure 3. The analysis yielded significant results for the main effects for "Condition," F(4, 194.431) = 19.764, $p < .001$, $d = .22$ and "Session", F(3, 249.264) = 52.928, $p < .001$, $d = .36$ and an interaction effect for "Session" and "Condition," F(12, 249.264) = 2.013, $p = .024$, $d = .07$.

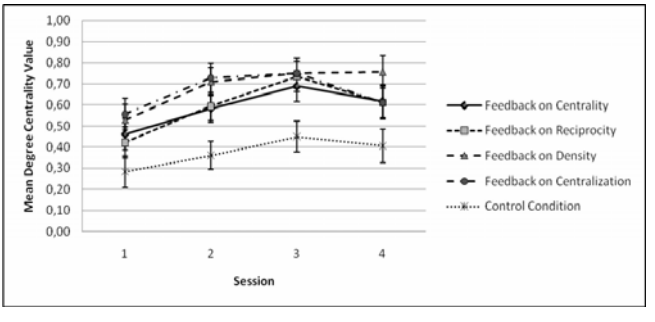


**Fig. 3.** Mean values of degree centrality in each experimental condition and in the four sessions of the game. Error bars correspond to 95% Confidence Intervals.

During Session 1, all feedback conditions except for reciprocity were higher than in the control condition. From the second session onwards, all feedback conditions differed from the control condition. The initial difference with control, due to coincidence, was maintained steadily during all sessions. However, given that groups in the feedback condition differed from the controls since the first session, it is not possible to attribute the differences in the subsequent sessions to feedback alone.

### 3.3 Effects on Reciprocity

The effects of all types of feedback on reciprocity are shown in Figure 4. The analysis yielded significant results for the main effects of "Condition," F(4, 186.873) = 15.673, $p < .001$, $d = .28$ and "Session," F(3, 290.570) = 11.140, $p < .001$, $d = .67$ and for the interaction between "Session" and "Condition," F(12, 290.570) = 2.462, $p = .004$, $d = .25$. Comparisons of estimated marginal means showed no significant difference

during the first session. In the second and third sessions, no differences were found between any feedback condition and, excluding Centralization, all conditions yielded a higher reciprocity value than did the control condition. Differences among feedback and control conditions remained in the fourth session, where reciprocity scores were also higher with reciprocity feedback compared to the other types of feedback. Centrality and density feedback were effective but less so than reciprocity feedback in the fourth session. Feedback specificity seems to have played a role here. In addition, since reciprocity was effective on reciprocity feedback in the fourth session, this aspect of communication was not affected by fatigue as hypothesized in [6]. This notion influenced H2 and will be discussed in the conclusion.

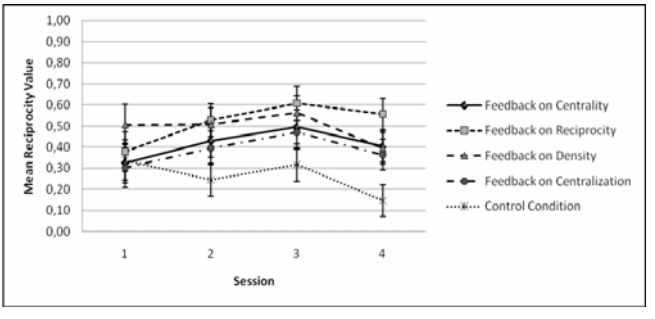


**Fig. 4.** Reciprocity values in each experimental condition and in the four sessions of the game. Error bars correspond to 95% Confidence Intervals.

### 3.4 Effect on Density

Regarding the effect on density, a graphical representation of the mean values of density and how they varied across the different conditions is displayed in Figure 5. This analysis yielded significant results for the main effects of "Condition," $F(4, 15) = 5.985$, $p = .004$, $\eta^2 = 0.51$ and "Session," $F(3, 45) = 18.280$, $p < .001$, $\eta^2 = 0.61$. There was no significant interaction between "Session" and "Condition," $F(12, 45) = 2.462$, ns, $\eta^2 = 0.068$. As was the case for degree centrality, it is not possible to attribute any subsequent difference to the feedback and was not possible to test this hypothesis.

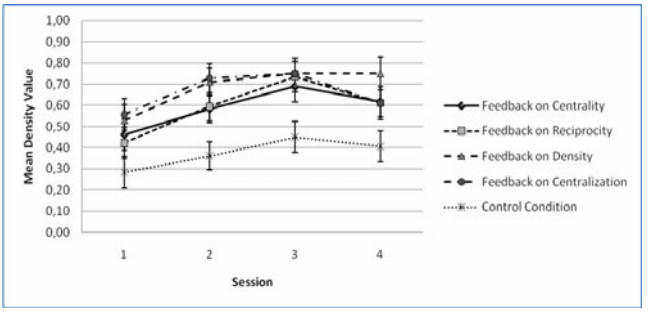


**Fig. 5.** Density values for each condition in the four sessions of the game. Error bars correspond to standard errors.

### 3.5 Effect on Centralization

The results for centralization are displayed in Figure 6. The analysis yielded significant results for the main effects for "Session," $F(3, 45) = 4.826$, $p = .005$, $\eta^2 = 0.20$. There were no significant main effects for "Condition," $F(4, 15) = .583$, ns, $\eta^2 = 0.12$ and no significant interaction between "Session" and "Condition," $F(12, 45) = .943$, ns, $\eta^2 = 0.16$. Therefore, it seems that this value decreased from the first to the third session, regardless of the presence of feedback.

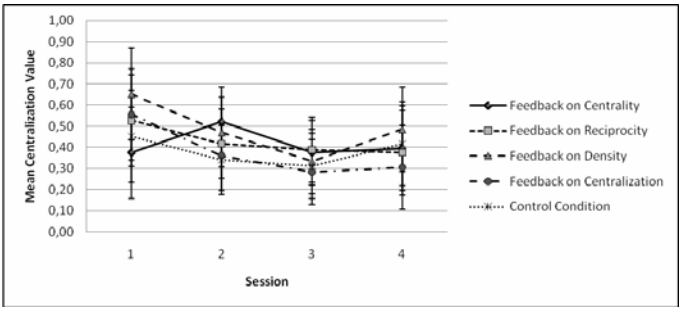


**Fig. 6.** Centralization values for each condition across the four sessions of the game. Error bars correspond to standard errors.

## 4 Discussion and Conclusion

Finding the proper cue to influence how users communicate in a mediated environment has always concerned scholars in human-computer interactions [20]. The study reported here examined the effects of a class of augmenting cues (i.e., SNA feedback) on group communication.

The effect on the number of messages exchanged (H1) was confirmed for all types of feedback. Stability (H2) was also confirmed: the effect persisted until the third session and afterwards decreased for reciprocity and centralization feedback. However, the explanation for this decrease is not as we originally hypothesized. Specifically, reciprocity feedback did not lose its effectiveness on reciprocity behavior, only on the general amount of messages exchanged. Thus, reciprocity cannot be considered as generally prone to fatigue as we thought in H2. Rather, it is possible that reciprocity feedback decreased its effect on the exchange of messages because it is not a generic dimension of communication, but a specific one; it is more related to message quantity than to message direction. In fact, feedback based on message quantity (centrality and density) was able to maintain longer effects. This result suggests that specificity affected (H3) reciprocity behavior, as hypothesized, but it also affected message quantity.

Specificity effects were not found on centralization, degree centrality, or density. Since there was an initial difference due to sampling error in degree centrality and density among conditions, despite homogeneity in demographics, we can only affirm that differences found in the first session for these indices were maintained consistently during all sessions, without knowing if they were due to the feedback or to other

differences between the groups. Regarding centralization, there may by other reasons for the lack of effect, which was probably connected to the nature of the task. Centralization concerns the level of hierarchization in the communication structure of the group. Because the goal of communication in this study was to circulate information, participants were unable to predictable who found this information; therefore, centralizing communication was not beneficial to the task. This finding can explain why centralization decreased, regardless of feedback, and suggests that the task can play an important role in defining what feedback information is used and how.

In conclusion, each feedback affected at least some dimensions of communication and did so steadily. Therefore, SNA-based feedback can profitably be integrated in electronic communication systems to support user awareness of group interactions. The specificity of the feedback, with respect to the targeted behavior, plays a role in determining its effectiveness. This finding has important consequences in designing a feedback service. In case that service is not customized on a specific activity, it is recommended that designers provide a repertoire of different feedback types that users can chose from based on the needs of their activities. Finally, further studies are needed to examine the role of the task in mediating the feedback effect.

**Acknowledgments.** The study reported here is partially funded by the PASION project (Psychologically Augmented Social Interaction over Networks, reference number 27654 PASION, EU IST program). All authors contributed equally to this work.

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