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Improving productivity and creativity in online groups through social comparison process: New evidence for asynchronous electronic brainstorming

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Abstract

This article extends the findings in synchronous room-based electronic brainstorming about the impact of social comparison process on productivity and creativity in a web-based context of asynchronous electronic brainstorming. Social comparison was manipulated with a feedback informing group members of their respective contributions on the electronic brainstorming task through a shared table regularly updated by a facilitator. In another group, although participants had the possibility to identify each contribution within the newsgroup, they did not receive any feedback in a shared table. Results showed that both group productivity and group creativity are better in the social comparison feedback condition than in the other condition. It appears that social comparison process has a positive impact on productivity and creativity in a web-based context of asynchronous electronic brainstorming, but only when participants have access to a shared table facilitating the comparison among group members. This finding provides some useful recommendations for learning facilitators to improve productivity and creativity in the context of computer-supported collaborative learning over the Internet. It also invites to future innovative technological developments to improve participation in online groups.

Keywords: Social comparison; Electronic brainstorming; Computer-supported collaborative learning; Creativity; Internet

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1. Introduction

The use of computers and communication systems as support for human cooperative work dates back to the early 1980s (e.g., Huber, 1980). From that date, new forms of computer technology – called Group Support Systems (GSS) – have increasingly developed. Such systems, often called *groupware*, are defined as computer-based network systems which support group work on a common task and provide a shared interface for participating groups (see Ellis, Gibbs, & Rein, 1991). DeSanctis and Gallupe (1987) defined GSS as combining "*communication*, *computer*, *and decision technologies to support problem formulation and solution in group meetings*" (p. 589). These systems were initially developed for commercial use, usually to support decision making processes in organization. They have been widely used for research on electronic brainstorming in groups in which participants generate ideas on computers (see Fjermestad & Hiltz, 1998, for a review). A large majority of studies examined electronic brainstorming in a synchronous room-based context, although the development of Internet has provided over the last years a web-based context without space nor time constraints for testing new forms of electronic brainstorming. The present study does not only extend electronic brainstorming research, shifting from synchronous room-based context to an asynchronous web-based one, but also provides a new test for the impact of social comparison process on productivity and creativity in on-line groups during an asynchronous electronic brainstorming.

1.1. Room-based studies

With electronic GSS, group members communicate by exchanging typed messages, instead of verbally speaking in a meeting room (e.g., Nunamaker, Dennis, Valacich, Vogel, & Georges, 1991). Numerous laboratory and field studies have used GSS to facilitate different types of work and learning methods in different tasks such as communication, planning, voting, negotiation, decision-making, problem-solving, idea generation, and so on. These tasks can be accomplished by using specific instruments such as electronic brainstorming, idea organization, vote, and group writing. GSS's have been essentially used for electronic brainstorming in groups [1] and have proven useful in improving group performance, particularly for creativity tasks such as idea generation (e.g., Gallupe, Bastianutti, & Cooper, 1991; Nunamaker, Applegate, & Konsyski, 1987; Pinsonneault, Barki, Gallupe, & Hoppen, 1999). This form of brainstorming consists in groups of various sizes simultaneously and anonymously generating ideas on a specific issue on individual computers located in a same electronic meeting room. Individual computers are connected to a central computer which collects the generated ideas and controls their display on a large screen at the

[1] Group brainstorming is a popular technique for creative idea generation developed by Osborn (1957). This technique consists in following a set of four rules designed to establish a non-evaluative setting and to enhance the idea generation process: (a) criticism is ruled out, (b) free thinking is welcome, (c) quantity is wanted, and (d) combination and improvement are sought.

front of the room (or on part of the screen). Participants share ideas through typing them on a network-linked computer (a *computer console*) which is running group brainstorming software (see *GroupSystems*, Nunamaker et al., 1991). Because participants have to gather at the same time in a same place, the room-based studies have been limited to small groups. Indeed, among 200 experiments listed by Fjermestad and Hiltz (1998) in their review about GSS, only 4% used groups with 10 members or more. Since then, researchers have tested new forms of electronic brainstorming for larger groups in a room-based context. For example, De Vreede, Briggs, van Duin, and Enserink (2000) separated very large groups into sub-groups which had to generate ideas in a serial mode. Once a sub-group had finished to produce ideas, the next began, and so forth until all the sub-groups had performed the task. Although this technique appeared to be more efficient than a technique in which sub-groups worked in a parallel mode, the sub-group members were involved in a synchronous electronic brainstorming task in a traditional room-based context. Because this technique did not eliminate the time and space constraints, and because there may be more group members than there are GSS workstations in the electronic meeting room, other forms of electronic brainstorming may be developed today over the Internet.

1.2. Web-based studies

Although the original GSS's were room-based, with strong time and space constraints, the development of the Internet has enabled new forms of electronic brainstorming providing possibilities for individuals to work with others who are geographically remote. The main advantage of this form of electronic communication is that both temporal and spatial constraints are abolished (e.g., Arrow et al., 1996; Cummings, Schlosser, & Arrow, 1996; Gay & Lentini, 1995; Kiesler & Sproull, 1992). There is a new form of GSS derived from Internet such as web-based systems which incorporate various communication tools, synchronous and asynchronous, and can be used by individuals working together. However, when people work together, there is often a need not only to communicate with others but also to share information. That is the reason why shared workspaces are used in the today GSS for the storage of different kinds of information data such as documents, tables, pictures, URL links to web pages, member contact information, and so on. Although many GSS have evolved to the increasingly popular and ubiquitous Internet applications that enable participants to communicate with other group members over the web, the electronic brainstorming remains dramatically synchronous. However, the synchronous mode of communication of web-based GSS confronts people to serious agenda problem reducing the interest for these systems. Consequently, it is often very difficult to support very large groups in a single web-based GSS meeting although the use of room-based electronic brainstorming plays a key role in enhancing productivity in groups, particularly for larger groups (e.g., Valacich, Dennis, & Connolly, 1994). On the contrary to traditional GSS, asynchronous computer conferencing systems such as newsgroups provide many participants with an opportunity to work together without time nor space constraints. Although Computer-Mediated Communication (CMC) has been used in GSS

studies, researchers and practitioners have rarely used a traditional asynchronous computer conferencing, i.e. a newsgroup, to conduct an electronic brainstorming session in a web-based environment. One of the objectives of the present study is to use this mode of communication for electronic brainstorming.

Apart from the technological environment in which electronic brainstorming can be used, some studies on electronic brainstorming have been guided by group processes which improve (or impair) performance, respectively for individuals – who firstly separately work (without communicating) and later on pool ideas (i.e. nominal groups) – and persons involved in verbal brainstorming (e.g., Gallupe et al., 1991; Valacich et al., 1994; Ziegler, Diehl, & Zijlstra, 2000).

1.3. Group processes in electronic brainstorming

Several dozen group processes have been studied in controlled experiments on group computer-supported brainstorming such as production blocking [2] (Diehl & Stroebe, 1991), evaluation apprehension (Brown & Paulus, 1996), social loafing (Karau & Williams, 1995), social comparison (Shepherd, Briggs, Reinig, Yen, & Nunamaker, 1996), and so on.

It appeared that one of the most important advantages of electronic brainstorming is that it reduces or eliminates the harmful blocking effects which appear in verbal brainstorming (e.g., Diehl & Stroebe, 1987; Gallupe, Cooper, Grise, & Bastianutti, 1994; Valacich et al., 1994). Indeed, because nobody in the group has to wait for a turn to speak, production blocking is eliminated during a synchronous electronic brainstorming session (e.g., Gallupe et al., 1991; Paulus, Legett-Dugosh, Dzindolet, Coskun, & Putman, 2002). However, production blocking is not eliminated by the synchronous mode of communication *per se*, but rather by the possibility to generate ideas at any moment into a shared workspace, either synchronously or asynchronously. Another advantage of electronic brainstorming is to reduce evaluation apprehension (e.g., Connolly, Jessup, & Valacich, 1990). The anonymity of electronic brainstorming reduces the threat to be negatively evaluated by other participants. However, this advantage can also be detrimental to productivity in groups because anonymity also encourages participants to loaf. Social loafing is the process by which individuals tend to make less effort in group tasks than they do in individual tasks, unless their individual contributions can be identified (e.g., Diehl & Stroebe, 1987; Latané, Williams, & Harkins, 1979; Shepperd, 1993). Alternative to original electronic brainstorming which promotes anonymity of group members, an electronic

[2] Production blocking refers to the need to take speaking turns in verbal brainstorming (Diehl & Stroebe, 1987, 1991). During a verbal brainstorming session, participants have to coordinate their idea generation with other group members and they need to share the allowed time with others. In addition to coordination and time constraints, group brainstorming may actively interfere with the ability to generate ideas: when participants are prevented from contributing an idea when they first think of it, they may self-censor because their ideas seem less relevant or original. Similarly, if they try to retain an idea, they must focus on remembering it, which prevents them from generating new ideas or paying attention to the ideas of others.

brainstorming through a traditional newsgroup may provide an identification of the contributions of group members and, consequently, reduce social loafing. In addition, identification is likely to provide group members with an opportunity to compare to each other. Social comparison processes are known to be an important determinant for group behaviours and performance, even in electronic brainstorming.

1.4. Social comparison processes: Upward comparison and downward matching

Since their origin, the social comparison processes have been known to be useful for self-evaluation and self-improvement. Indeed, Festinger's (1954a, 1954b) theory of social comparison processes postulates that there is a "*motivation to know that one's opinions are correct and to know precisely what one is and is not capable of doing*" (p. 217). Although people prefer objective standards to evaluate themselves, these are hardly available. Under such circumstances, people compare to each other to assess their standing and they prefer "similar others" to "dissimilar ones". Consequently, there is a trend to stop comparing oneself to others when they are very different.

Regarding ability, Festinger (1954a, 1954b) postulates that there is a "*unidirectional drive upward*" in which people make ability comparisons, in particular with "similar others" who are marginally better than themselves. This upward comparison process is generally a good incentive for self-improvement (e.g., Helgeson & Mickelson, 1995; Wood, 1989). Indeed, viewing others performing slightly better than themselves may lead people to set higher personal standards which can motivate efforts to improve themselves, and by doing so, they improve themselves (e.g., Blanton, Buunk, Gibbons, & Kuyper, 1999; Huguet, Dumas, Monteil, & Genestoux, 2001; Seta, 1982; Vrugt & Koenis, 2002). For example, in an academic context, Blanton et al. (1999) found that the academic performance feedback of Dutch school children tended to improve if they compared their examination grades with high-performing students (see also Huguet et al., 2001 for studies among French school children). Similarly, Vrugt and Koenis (2002) recently showed that upward comparison produced higher personal goals which predicted the future scientific productivity of academic staff members.

However, the presence of very productive members in a group could motivate increased performance in the other group members, but only if the *downward matching process* can be counteracted or minimized (Paulus et al., 2002). Downward matching is the process by which social comparison leads to lower standards for performance when generating ideas within groups. Indeed, over contributors tend to reduce their contributions to match the group's poor standards, whereas under contributors are challenged to reach the level established by others (Forsyth, 2000). This process tends to lower overall performance levels, also in groups working via computers (e.g., Paulus, Larey, Putman, Leggett, & Roland, 1996), but it can be reduced by increasing a comparison among group members (e.g., Brown & Paulus, 1996; Paulus & Dzindolet, 1993). Indeed, electronic brainstorming studies in room-based context have demonstrated that group members who could monitor others' ideas production in real time eliminated downward matching during an idea

generation task (e.g., Paulus et al., 1996; Roy, Gauvin, & Limayen, 1996; Shepherd et al., 1996). Consequently, brainstorming groups are more productive when they are provided with a continuous public display of the ideas generated by anonymous group members projected at the front of the electronic meeting room. Similarly, in a study in which participants announced to the group how many ideas they generated every 5 min, Paulus et al. (1996) demonstrated that the shared performance feedback increased productivity, compared to the "no feedback" condition.

Taken together, these results suggest that techniques which provide a real-time – or a delayed performance feedback – seem particularly useful to improve productivity because they create many opportunities for social comparison within the group. Thus, social comparison process is not only useful to evaluate oneself accurately by viewing the performance of group members, but also to improve one's productivity in group through comparison with (slightly) more productive participants (e.g., Monteil & Huguet, 1999).

1.5. Overview and hypothesis

The present research aimed to test the influence of the social comparison process in a web-based electronic brainstorming context in which geographically remote participants asynchronously generate ideas in a newsgroup. Participants were randomly assigned in one of the two gender balanced groups. In one group, social comparison was possible through a feedback which informed participants of their own contributions and those of each member within the group by using a shared table regularly updated. In the second group, treated as a control condition, participants did not receive any feedback in a shared table although they had the possibility to identify contributions of group members in the newsgroup.

Consistent with findings on room-based studies (Roy et al., 1996; Shepherd et al., 1996), it was assumed that participants who received a feedback of social comparison through a shared table should be more productive than those who did not receive any feedback. Although there is a lack of empirical evidence, it was also assumed that the same pattern should be observed on group creativity measured through the quality of ideas generated in electronic brainstorming.

2. Method

2.1. Participants

Participants were 27 adult learners (15 males, 12 females) enrolled in a "realistic" on-line distance learning session about Computer-Supported Collaborative Learning (CSCL). By "realistic" we meant that all participants (adults students) volunteered to participate in a lifelong learning and training programme. A majority of participants ($N = 23$) were University professional on-line instructors or consultants in on-line training organizations in France. The four remaining participants were in charge of computer science.

2.2. Equipment

A commercial Web-based groupware (Inter-Note™, A6 Mediaguide) was used to enable and support cooperative work among geographically remote groups of participants. This groupware system provides useful functionalities for managing on-line groups through an administrator entry. For example, the administrator can easily form groups and sub-groups of different sizes and manage these groups, adding and removing group members. When participants are registered in a given group, they can have access to the workspaces of their group by typing their user name and password. Among the numerous functionalities provided by the groupware system, two main functions were used by participants in the present study: (1) asynchronous exchange of textual messages in a newsgroup and, (2) storage of documents in a shared space for the group.

2.3. Procedure

During the initial face-to-face meeting, participants were informed by the instructor (called facilitator [3] in the present study) that they would be participating to a set of on-line group activities in a remote context. They were informed that they would receive the work instructions when they would come back to their work place and would meet in a same virtual learning space through a groupware system. At the beginning of the face-to-face meeting, participants received a pre-task questionnaire measuring their attitudes towards information and communication technologies for distance learning, group learning, and their familiarity with the main communication technologies for on-line distance learning. Then, participants got to know each other and were also trained to log the groupware system, to use the newsgroup, to download documents from a shared workspace of the server to their personal computer and, inversely, to upload documents from their computer to a share workspace.

At a distance, participants were randomly assigned to two groups by the facilitator using the administrator entry of the groupware, with the constraint that to ensure equivalent gender balance between the two conditions, each group should approximately count the same number of male and female participants. Before the experimental manipulation was introduced, participants had received written instructions on how to brainstorm and on the topic they would have to address together. On an introductory web page, participants read the brainstorming rules established by Osborn (1957, see Footnote 1) and the topic of the brainstorming activity. In a ''realistic'' distance learning session about computer-supported

[3] In a computer-supported collaborative learning environment, the role of the instructor shifts from ''knowledge expert'' to learning facilitator whose primary role is to guide and support the learning process by setting up different types of learning methods that involve group interaction such as debate, role-play, project work, and brainstorming. As in verbal brainstorming, the facilitator has to manage the idea-generation and to guide the decision-processes within groups. Among other things, he/she presents the brainstorming rules, encourages continued idea generation during periods of inactivity, and sets goals for the group.

collaborative learning, participants were given the task to express as many ideas as they could about different groups and teams they knew of in their daily life. The following instruction was written on a web page: "*What's a group? Indicate all examples you can imagine to be representative of groups or teams. You can generate ideas at any moment within the newsgroup*". The reason of this was to introduce the notions of group and team in a social psychological approach to the participants before they would themselves have to design on-line activities in a CSCL context. Groups were given five days to generate ideas, and the facilitator was not involved during this period. Participants were invited to get organized to produce ideas within the newsgroup, the only constraint was to fill in an individual table in which they had to indicate the session number (from min = 1 to max = 5), the number of ideas generated in the session, and the estimated time spent reading and writing ideas within the newsgroup during the session. Individual tables were to be sent to the facilitator by e-mail after each "log in". The facilitator used the data of these individual tables to update the shared table in the social comparison condition and to complete a statistical file in both conditions. Of course, the facilitator checked within the newsgroup the accuracy of the data contained in the individual tables.

In a first condition (experimental), participants received a feedback of social comparison through a shared table which could be read at any moment by group members. The shared table was a double-entry matrix in which name and first name of each group member was written in a raw, together with their task contributions in columns. In the present study, it was the facilitator's task to update the shared table whenever an individual table was received by e-mail. It was also the facilitator's task to upload the shared table on the shared workspace of the group. The date and the hour of the last modification were indicated at the top-left of the shared table for each updating. Three contribution and performance criteria were recorded in the columns of the shared table: (a) number of ideas, (b) number of newsgroup's logs, and (c) time spent reading and writing ideas within the newsgroup (see Appendix A).

In a second condition (control), participants did not receive any feedback of social comparison although they had the possibility to identify each contribution of group members within the newsgroup. The same criteria were recorded in a data file for statistical analyses and in a same table which was not given to group members. (This table was to be used at the end of the electronic brainstorming task during a debriefing session.) This control condition was similar to traditional newsgroups in on-line environments in which participants did not have the opportunity to visualize the level of contributions of group members at a glance. Thus, on the contrary to the experimental condition, participants had not the opportunity to easily compare their contribution to those of their group members.

Eventually, the facilitator invited participants of both groups to discuss and analyse their on-line behaviours during a debriefing session through a newsgroup. After distributing the shared tables of both conditions, the facilitator asked the participants to discuss the utility of the shared table given in one condition. The names of the participants were systematically deleted in the shared tables to ensure confidentiality. The experiment finished when no message had been posted in the newsgroup for two days. To conclude, the facilitator explained the purpose of the study

and justified the manipulations by delivering a short document about the group processes involved in an electronic brainstorming.

2.4. Dependent measures

2.4.1. Pre-task questionnaire measures

A questionnaire measured attitudes of participants towards information and communication technologies (ICT) for distance learning and their attitudes towards group learning on a series of 5-point rating scales (from 1 = *strongly disagree* to 5 = *strongly agree*). Attitude towards information and communication technologies for distance learning was measured through the three following items: "*I believe that ICT are promising for the future of distance learning*", "*In my opinion, ICT are useful for distance learning*", and "*I think that ICT improve the quality of distance learning*" (reliability, Cronbach's $\alpha = 0.87$). Attitude towards group learning used the two following items: "*In my opinion, learning in group is better than learning individually*", and "*I think that group learning produces a greater amount of knowledge*" (Cronbach's $\alpha = 0.79$). At the end, the questionnaire measured the familiarity of participants with communication technologies such as browser, e-mail, newsgroup, chat, and web cam on a series of 5-point rating scales (from 1 = *very unfamiliar* to 5 = *very familiar*).

2.4.2. Task-related measures

The three measures used in the shared table were directly explored for statistical analyses: (a) number of ideas generated, (b) number of newsgroup's logs, and (c) time spent reading and writing ideas within the newsgroup. Only the first measure was used to examine productivity in groups. This productivity measure consisted in counting the number of non-redundant ideas. One coder scrutinised all the ideas and eliminated ideas that had been given more than once within the group. The count of the remaining ideas gave the number of non-redundant ideas (Dennis & Valacich, 1993; Diehl & Stroebe, 1991; Gallupe et al., 1994). An additional measure of performance consisted in investigating creativity through the perceived originality of each ideas. The newsgroup's record of the list of the non-redundant ideas previously identified by a coder was printed out for each group. The originality of ideas for each participant was assessed independently on a 1–5 Likert scale (from 1 = *poor* to 5 = *good*) by two female raters, on-line tutors in distance learning environments, who were blind to the condition. Because interrater agreement was good ($r = 0.81$) the ratings were combined and averaged to provide a single composite score of creativity for each participant.

3. Results

3.1. Pre-task questionnaire: Familiarity and attitudes towards technologies and group learning

Analyses of the pre-task questionnaire revealed that all participants were used to computers, the Internet and to asynchronous technologies for learning (*range* = 1–5;

browser: $M = 4.67$, $SD = 0.7$; e-mail: $M = 4.91$, $SD = 0.4$; newsgroup: $M = 3.27$, $SD = 0.9$. They were relatively less familiar with the use of synchronous technologies (*range* = 1–5; chat: $M = 2.41$, $SD = 1.3$; web cam: $M = 1.67$, $SD = 0.7$). Results did not reveal any difference between experimental and control condition on each of these measures, nor on attitudes towards information and communication technologies for distance learning and group learning (see Table 1). It may be noticed that although the attitudes towards information and communication technologies for distance and group learning between the two groups were not significant, they all slightly favored the control group for unclear reasons.

3.2. Task-related measures

Three measures examining performance and contributions within groups were explored for statistical analyses: (a) number of ideas generated, (b) number of newsgroup's logs, and (c) time spent reading and writing ideas within the newsgroup. In addition to these measures, group creativity was also assessed in the present study.

The distributions of the scores for these measures deviated from normal distributions. The Kolmogorov–Smirnov goodness-of-fit test yielded significant results for all distributions. For the number of participations within the newsgroup: K–S $Z = 1.06$, $p < 0.04$, for the number of ideas generated within the newsgroup: K–S $Z = 1.4$, $p < 0.03$, for the time spent reading and writing ideas within the newsgroup: K–S $Z = 1.5$, $p < 0.03$, for the creativity scores: K–S $Z = 1.6$, $p < 0.02$. These deviations from a normal distribution were also apparent when the distributions were separately tested for the two feedback conditions. Moreover, Levene's test for equality of variances between conditions revealed a lack of homogeneity for each dependent measure, except for creativity. Therefore, employing an analysis of variance (ANOVA) or a t test for these dependent measures would not have been appropriate. Consequently, to examine whether there were differences in the contributions in the two conditions, a Wilcoxon rank-test was used; the Wilcoxon rank-test is like a t test for data which deviate from normal distribution (Bradley, 1968).

Table 1
Mean and standard deviation (in brackets) of attitudes and familiarity with technologies in the two conditions

	Condition of social comparison	
	Feedback ($N = 14$)	No-feedback ($N = 13$)
Attitudes		
ICT for distance learning	3.78 (0.5)	4.01 (0.5)
Group learning	3.65 (0.6)	3.81 (0.7)
Familiarity with communication technologies		
Browser	4.69 (0.5)	4.64 (0.9)
E-mail	5.00 (0.0)	4.82 (0.6)
Newsgroup	3.46 (1.4)	3.09 (1.2)
Chat	2.38 (1.3)	2.45 (1.4)
Web cam	1.62 (0.7)	1.73 (0.8)

Table 2
Mean rank, mean and standard deviation (SD) of each dependent measure in the two conditions of the study

	Condition of social comparison						
	Feedback ($N = 14$)			No feedback ($N = 13$)			Significance
	Mean rank	Mean	SD	Mean rank	Mean	SD	
Productivity (number of non-redundant ideas)	16.86	30.57	43.6	10.92	8.52	7.83	$p < 0.05$
Number of logs	15.39	2.21	0.89	12.5	1.77	1.4	*ns*
Time spent reading and writing ideas (min)	14.21	37.00	48.36	13.77	30.38	27.18	*ns*
Creativity (originality of ideas)	17.14	2.58	0.62	10.62	1.97	0.74	$p < 0.03$

The obtained mean rank of each dependent measure in the two conditions for the present study is presented in Table 2 (means and standards deviations are also provided in this table for information). The Wilcoxon rank-test showed that the number of ideas generated within the newsgroup was higher in the feedback of social comparison condition than in the non-feedback condition (Wilcoxon $Z = 1.9$, $p < 0.05$). The same pattern of results was found for creativity: the quality of ideas was higher in the feedback condition than in the non-feedback condition (Wilcoxon $Z = 2.1$, $p < 0.03$). The feedback condition and the non-feedback condition did not differ for other measures (number of participations: Wilcoxon $Z = 0.9$, *n.s.*, and time spent reading and writing ideas: Wilcoxon $Z = 0.1$, *n.s.*). Correlational analyses revealed that creativity scores were not related with productivity scores ($r = 0.08$, *ns*) suggesting independence between these measures.

3.3. Additional descriptive data

In addition to quantitative data, we also collected some qualitative information in the form of written comments during an on-line debriefing session. Participants were given the opportunity to analyse the performance of the two groups and to discuss the utility of the shared table given in the experimental condition. The content of the discussion between participants suggested that social comparison process was at work during the asynchronous electronic brainstorming when participants had access to a shared table presenting the contribution of group members. However, deeper analyses of the comments revealed positive and negative aspect of the social comparison process (see Table 3).

4. Discussion

The present research aimed at transferring what happens in a synchronous room-based electronic brainstorming – as for the impact of social comparison process on performance – into a web-based context (asynchronous electronic brainstorming).

Table 3
Qualitative data (comments about human activities during the asynchronous electronic brainstorming in the feedback condition)

Negative comments	Positive comments
I have had a look at the shared table every time I logged in the newsgroup. I have observed the number of contributions, hence the feeling of assessment by the group. This has not enhanced my contribution at all (CS, female)	I remember consulting the table on a very regular basis once I had posted my contribution to assess the group evolution and my position within the group ... to see if I was in a good position (GP, male)
I have had a look at the shared table three or four times, but viewing the great number of ideas and the time spent by others has been a key to relief (DB, female).	The shared table is to me a good incentive just as self-correction or feedback (DA, male)
The table seems to be a tool for the facilitator but is by no way a federative element for the group (EE, male)	It seems that the shared table has played an emulative role for me (HV, male) I have checked the shared table very closely to assess any contribution in comparison to that of others (BN, male)

Based on room-*based* studies (Roy et al., 1996; Shepherd et al., 1996) as well as on theoretical arguments about social comparison theory (Festinger, 1954a, 1954b), we expected that participants who were to receive a feedback of social comparison through a shared table would be more productive than those who did not receive feedback. It was also assumed that the same pattern should be observed on creativity measured through the quality of ideas generated by participants during the asynchronous electronic brainstorming task. As assumed, results revealed that individuals with a basis for social comparison on a shared table for their on-line group outperformed individuals with no basis for social comparison. However, the difference between the feedback condition and the control condition was only observed in the number of non-redundant ideas generated and in the originality of ideas. No differences were observed neither in the number of newsgroup's logs or in the estimated time spent reading and writing ideas in the newsgroup. These results suggest that different patterns of productivity and creativity between the two conditions cannot be explained by the time participants spent in the newsgroup, nor by the number of sessions in which they participated. Thus, participants who had access to the shared table did not focus on information about time and number of newsgroup's logs, but rather on the number of ideas produced by other group members, which is the core of a brainstorming task. Eventually, additional analyses did not reveal a correlation between the number of ideas and the creativity scores. This lack of correlation suggests that creativity does not depend on the proportion of ideas generated in the newsgroup, but is rather to be considered as the result of an individual effort to find original ideas relatively to other group members.

Taken together, these results suggested that social comparison process was as much at work in asynchronous web-based environments as in traditional synchronous room-based electronic brainstorming studies performed in laboratory settings (see Roy et al., 1996; Shepherd et al., 1996). When participants viewed the contributions of each group member in the shared table, they adjusted their performance

level during the idea-generation task increasing the overall group performance. By contrast, although the contributions of group members were identifiable in the newsgroup of the control condition, participants did not use this information to improve their productivity and creativity. Consequently, providing a shared table of each member's contributions seems to be a fruitful strategy to improve performance in an asynchronous electronic brainstorming.

In the present study there has also been a shift from the quantity to the quality of ideas. Indeed, quality was measured in the present study through the originality of ideas given by each group member providing a creativity index. Although the shared table did not mention this criterium during the electronic brainstorming, participants seemed to have increased their efforts to produce originality ideas. Social comparison process engaged participants in making a greater effort to do better than their co-workers in creativity when they were engaged in a comparison on the basis of productivity criteria. Maybe this result reflected a strategy of participants to differentiate from other group members on creativity while they could not do that on productivity. However, the lack of correlation between the two measures suggests that we should be precautious as for this interpretation. Indeed, in the case of a differentiation strategy, we should have observed a negative correlation, which is not the case here.

The present study shows that traditional technologies such as newsgroups can be useful to improve the use of electronic brainstorming in an on-line learning context, provided participants have the opportunity to compare their contribution to that of other group members in a shared table regularly updated by a facilitator. According to Festinger's (1954a, 1954b) social comparison theory, participants are likely to make comparisons with others who are slightly better than themselves (*unidirectional drive upward*). This process encourages participants to compare to group members performing slightly better than themselves through the shared table, which is likely to motivate their personal efforts to improve themselves. Although somewhat speculative, this proposition can be supported by an experiment about social comparison choices examining this process (Wheeler, 1966). This experiment demonstrated that when individuals had the possibility to view the scores of their group members, they were likely to compare to someone better to assimilate with her/himself (see Collins, 2000). In contrast, very few chose a downward comparison target by avoiding viewing the scores of someone performing worse. Thus, upward comparison is known to be motivated by self-evaluative and self-improvement needs (e.g., Seta, 1982; Wood, 1989) whereas downward comparison is likely to be motivated by self-protection and self-enhancement needs (e.g., Wills, 1981). More important, some studies suggested that viewing others performing slightly better than themselves may lead people to improve their performance (e.g., Blanton et al., 1999; Huguet et al., 2001; Seta, 1982; Vrugt & Koenis, 2002). However, because we did not know in the present study exactly what participants did with the data presented in the shared table, an alternative interpretation to Festinger's (1954a, 1954b) *unidirectional drive upward* might be suggested. For example, participants might have made a mental calculation of the average contribution of group members and might have responded to that perceived average number rather than to that of the slightly better performers. However, such interpretation may not be valid. Indeed, Festinger's (1954a, 1954b) social comparison theory

also assumed that a large difference between self and others would result in the cessation of social comparison. In our study, this process is probably at work, as the data about standard deviation seem to suggest that the standard deviation is higher in the experimental condition than in the control one (see Table 2). In other words, some people stopped comparing when the discrepancy between themselves and others became too large. A comment of one participant illustrates this process and the resulting discouragement ("*...viewing the great number of ideas and the time spent by others has been a key to relief*", DB). Although empirical evidence is lacking about the direct influence of social comparison in productivity and creativity in on-line groups, theoretical arguments about social comparison process authorize some inferences about its potential role in an asynchronous electronic brainstorming task using a traditional computer conferencing system. Future research should examine more accurately the way participants used the shared table to engage either in upward or downward comparison, but also as for the motives supporting their comparisons (e.g., self-evaluation, self-improvement). Indeed, when they work together in a group, participants are generally uncertain about their relative expertise, knowledge, or contribution on a given task. This difficulty needs to be resolved because group's ability to recognize the expertise of its members is known to be vital to the group's success in face-to-face environments (e.g., Einhorn, Hogarth, & Klempner, 1977; Libby, Trotman, & Zimmer, 1987). Consequently, information on the relative expertise, knowledge, or contribution of each group member should be provided. Such information is likely to be very important in on-line groups in which participants are physically isolated from one another and only meet in a virtual shared space without information about their coworkers. In addition, to improve productivity and creativity in electronic brainstorming, we assume that the shared table given in the experimental condition may also reduce the uncertainty among group members by providing information about their performance. Thus, motives for self-evaluation as well as for self-improvement may be satisfied through the information contained in the shared table. An additional post-task questionnaire would be very useful to better investigate the motives underlying social comparison process during an asynchronous electronic brainstorming. Because post-experimental measures are lacking in the present study, it is difficult to know exactly what are the motives underlying the consultation of the shared table. In addition to the motives described above, participants may also be keen on competing with others, feeling guilt when they know that others are working harder than they are, feeling embarrassment or anxiety about what someone else might think of them, and so on. These issues suggest possibilities for fruitful future research about the motives underlying social comparison processes in on-line groups learning.

5. Limitations and future research

First of all, future research should extend these findings by collecting more data, so that we have a stronger quantitative basis for experimental statistics. Because the present research took place in a "realistic" context of group learning over Internet, the sample was limited to some experts in information and communication

technologies applied to learning. Nevertheless, this weakness (i.e., the number of participants involved in a study) is difficult to eliminate in a 'natural' setting which is necessarily more restricting at a methodological level.

Secondly, special attention should be paid to use a more realistic 'live' problem rather than a task which participants have not thought before of (see Shaw, Eden, & Ackermann, 2002). Consistently with much laboratory research on electronic brainstorming, the present study focused on the number of ideas generated by participants and on the quality of these ideas, considering brainstorming as an end in itself. In a more ''realistic'' context of on-line learning, such as computer-supported collaborative learning, brainstorming should be considered as a means to an end, and research should focus on the *usefulness* of the idea for personal learning in a real and complex problem-solving situation (Shaw et al., 2002). It may be interesting to use the brainstorming task to begin the process of exploring a problem, thus enabling the facilitator to use the brainstormed ideas later to help the group take a decision or produce a shared document. In this perspective, the present study provides some useful recommendations for learning facilitators on how to improve productivity and creativity in the context of computer-supported collaborative learning over the Internet.

Eventually, it may be useful to set up in innovative technological developments to improve participation in on-line groups. Indeed, the instrumentation of the shared table should be a further step to provide the facilitator which a tool for knowledge management in on-line groups. In the repertory of techniques that could be used by a facilitator, those invoking social comparison are particularly useful for improving productivity and creativity in on-line groups. For example, when using an instrumented shared table to monitor comparisons in on-line groups, it should be easy for the facilitator to reconstruct a group according to the performance level of each member (those who perform at a high level should be gathered in a same sub-group, whereas those who perform badly should remain together). Such intervention reduces the variability between the participants and contributes to the building of homogeneous groups in which comparisons to ''similar'' and ''slightly better'' others can take place. We need additional research to develop and test new ways in which groups can work together to generate ideas in a distributed asynchronous environment. Researchers should attempt to design new formats of brainstorming exploiting the new technologies available to them, such as asynchronous ones.

To conclude, it is widely understood that performance on simple or repetitive tasks such as brainstorming may be assumed to be more dependent on effort and persistence (i.e., dependent on individual motivation) rather than on cooperation and coordination activities. Because the lack of motivation is one of the major difficulty in on-line learning, a shared table providing a basis for social comparisons may be a useful tool to increase the motivation to contribute to newsgroups, thus reducing attrition.

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Appendix A

Shared table of the group members' contributions within the newsgroup*

Group members	Contributions within the newsgroup		
	Number of ideas	Number of logs	Time spent reading and writing ideas
Name and surname #1			
Name and surname #2			
Name and surname #3			
Name and surname #4			
...			
Sum:			

* Last update: 03-14-2002, 16 PM.

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