To cite this chapter: Buisine, S., Guegan, J., & Vernier, F. (2017). Technological innovation in group creativity. In: F. Darbellay, Z. Moody & T. Lubart (Eds.), *Creativity, Design Thinking and Interdisciplinarity*, chap. 12, Springer, Creativity in the Twenty First Century series.

# Chapter 16 – Technological innovation in group creativity

Stéphanie Buisine (1&2), Jérôme Guegan (2), Frédéric Vernier (3)

1. CESI, LINEACT
2. Université Paris Descartes, LATI
3. Université Paris-Sud, LIMSI-CNRS

## Abstract

This chapter presents on-going research dedicated to augmenting creativity through innovative technologies. Our hypotheses draw on the pros and cons of the Brainstorming paradigm to strengthen the former and overcome the latter. The main efficiency factors we are trying to support are Cognitive stimulation, Social comparison, and Group facilitation, while trying to circumvent Production blocking, Social loafing, and Self-censorship. The first technology reviewed is Electronic Brainstorming Systems: it was shown that such devices enable groups, even large ones, to avoid production blocking. However, it may also increase social loafing, which is detrimental to creativity. We then introduce Interactive Tabletop Brainstorming with which groups can conciliate individual reflection, idea sharing, and social setting. We show that this technology reduces social loafing and we provide interface designs that further support cognitive stimulation, social comparison and group facilitation. This series of experiments also highlight a new efficiency factor for creativity, namely the Fun factor: the use of innovative technology in itself introduces playfulness, which seems to increase engagement and creative performance. Finally, we report on a recent series of experiments exploring Avatar-Mediated Creativity as a means to counter self-censorship through anonymity and enhance creativity through avatars' appearance. The results confirm that the choice of avatars in virtual brainstorming greatly influences creativity through processes such as self-perception, priming, and social identity. In many respects, avatars and virtual environments offer a new promising tool to support group creativity. We conclude on the potential impact of these findings on real-world innovation challenges.

## Keywords

Technology; Electronic Brainstorming System; Interactive Tabletop System; Avatar.

## Introduction

Brainstorming remains one of the most widely used creative problem-solving approaches in group. This method was imagined by advertising executive Alex Osborn (1953) to help his collaborators reach higher levels of creativity. Osborn's first insight was to identify two antagonist mechanisms competing within the creative process, namely *ideation* and *evaluation*. Ideation relies on divergent thinking and consists in generating ideas, whereas evaluation supports convergent thinking and idea selection. In many respects, evaluation (e.g. "that's impossible / too expensive / ridiculous") interferes with ideation and acts as idea killer in the group (censorship) but also within one's own creative process (self-censorship). Therefore, Osborn's proposal to improve creativity consists in separating ideation and evaluation in time: in a brainstorming, participants should strive to defer judgment while generating ideas, and evaluate the pool of ideas only when the time has come. Four rules are provided to help participants suspend evaluation during ideation: *Withhold criticism*, *Welcome unusual ideas*, *Quantity breeds quality* and *Combine and improve ideas*. Subsequent research aiming to substantiate this method confirmed the efficiency of the four rules, since brainstorming sessions were shown to produce more creative ideas with than without the rules (Parnes & Meadow, 1959; Turner & Rains, 1965; Weisskopf & Eliseo, 1961). It was also observed that the presence of a facilitator (in particular an expert one), whose role is to ensure that the rules are respected, further enhances creativity (Kramer et al., 2001; Offner et al., 1996; Oxley et al., 1996; Paulus et al., 2006).

The brainstorming framework was also used in a considerable body of research to better understand the underlying processes of group creativity. For example, the exposure to other participants' ideas was shown to enhance individuals' creativity: this is termed *Cognitive stimulation* (Dugosh & Paulus, 2005; Dugosh et al., 2000; Nijstad et al., 2002). Besides, the possibility to compare one's own performance to the others' was also shown to increase creativity through *Social comparison* (Dugosh & Paulus, 2005; Bartis et al., 1988; Harkins & Jackson, 1985; Michinov & Primois, 2005; Paulus & Dzindolet, 1993). However, several characteristics of the brainstorming method also appeared to be detrimental to creativity. For example, a major shortcoming of spoken brainstorming sessions is the necessity of managing speech turns: each participant has to wait his turn to give an idea, and only one idea can be given within a turn. This severely interferes with ideation process (Nijstad et al., 2003) and results in *Production blocking* (Michinov & Primois, 2005; Diehl & Stroebe, 1987). *Social loafing* proved to be another key issue: in brainstorming groups, some participants tend to under-contribute in comparison to a situation where they would brainstorm alone (Harkins & Szymanski, 1988; Karau & Hart, 1998; Karau & Williams, 1993; Serva & Fuller, 1997), and other participants tend to over-contribute (*Social compensation* – Williams & Karau, 1991; McKinlay et al., 1999). The simultaneous occurrence of social loafing and social compensation results in the emergence of leaders and laggards in the group. Finally, despite brainstorming rules, *Self-censorship* remains a barrier to creativity (Williams, 2002). To summarize, Table 1 provides an overview of known efficiency and inefficiency factors of group creativity.

| | |
|---|---|
| **Efficiency factors for group creativity** | Group facilitation (Brainstorming rules + facilitator) |
| | Cognitive stimulation |
| | Social comparison |
| **Inefficiency factors for group creativity** | Production blocking |
| | Social loafing |
| | Self-censorship |

Table 1: Efficiency and inefficiency factors highlighted by research on brainstorming.

## Using technology to improve group creativity

Research on group creativity aims to provide tools based upon the aforementioned efficiency factors (or even strengthening them) while overcoming the inefficiency factors of the brainstorming method. This can be achieved through methodological and/or technological means. Hereafter we provide examples of technology-supported creativity tools and show how they are likely to enhance group creativity.

### *Electronic Brainstorming Systems*

Production blocking may be the easiest factor to counteract since it only requires switching from the spoken to the written channel for idea generation. The term *Brainwriting* (Heslin, 2009; Paulus & Yang, 2000) is sometimes used to refer to the technique of silently sharing ideas by writing them on paper or on digital notes. The latter can be done through an *Electronic Brainstorming System,* which consists in having the participants simultaneously generate ideas on computers networked together (Dennis & Williams, 2002). Electronic brainstorming proved to effectively supports group creativity: the same brainstorming rules apply and facilitator's task is made easier since the written channel is less prone to involuntary evaluation from participants. Moreover, it also supports cognitive stimulation by providing an increased attention to others' ideas (Michinov, 2012): it is indeed easier to read a large number of ideas on a computer screen than on e.g. sticky notes on a wall. Social comparison also applies to electronic brainstorming situations (Dugosh & Paulus, 2005; Michinov & Primois, 2005) and anonymity decreases evaluation apprehension (Nunmaker et al., 1991), which in turn may reduce self-censorship. Finally, electronic brainstorming avoids production blocking, which enhances idea production (Dennis & Valacich, 1993; Gallupe et al., 1991, 1994; Kerr & Murthy, 2004; Valacich et al., 1994), and this benefit was shown to increase with group size (Dennis & Williams, 2002; DeRosa et al., 2007; Paulus et al., 2013).

Table 2 summarizes the effects of electronic brainstorming systems: the efficiency factors previously identified in the literature are all supported, and a new one appears, namely group size. Regarding inefficiency factors, production blocking is avoided and self-censorship reduced. However, electronic brainstorming does not solve the problem of social loafing, and even increases its detrimental effects because group membership and sense of belonging are lower in this context (McKinlay et al., 1999). Following this pattern of results, we sought a compromise between electronic brainstorming and a setting enabling higher group awareness. This attempt led us to study the effects of interactive tabletop brainstorming systems, as developed in the following section.

| | | **Support provided by Electronic Brainstorming System** |
|---|---|---|
| **Efficiency factors for group creativity** | Group facilitation | ✔ |
| | Cognitive stimulation | ✔ |
| | Social comparison | ✔ |
| | Group size | ✔ |
| **Inefficiency factors for group creativity** | Production blocking | ✔ |
| | Social loafing | ✗ |
| | Self-censorship | ✔ |

Table 2: Effects of Electronic Brainstorming Systems on efficiency and inefficiency factors of brainstorming.

## *Interactive Tabletop Brainstorming*

Interactive tabletop systems are multi-user horizontal interfaces (Fig. 1). They implement around-the-table interaction metaphors allowing collocated collaboration and face-to-face conversation in a social setting (Shen et al., 2006). Interactive tabletop systems are particularly well suited for group creativity: in addition to supporting electronic idea generation, they provide sharing and visualization facilities on the table, enabling group members to do without individual computer screens. For this reason, they are expected to increase group awareness. To substantiate this assumption, we conducted a series of experiments using tabletop brainstorming systems, so as to understand the impact of the around-the-table form factor, of the digital nature of the tool, and of particular interface features on group performance.

Fig. 1: Example of an interactive tabletop brainstorming system (Schmitt et al, 2012).

As a first step, we compared interactive tabletop brainstorming with pen-and-paper brainwriting in several conditions. These experiments highlighted the importance of the around-the-table form factor to group performance, both in interactive and in pen-and-paper conditions (Buisine et al., 2012). More precisely, we observed groups of four members brainstorming around a table or in front of a vertical surface such as a flipchart. When group members were gathered in front of the flipchart, they exhibited high social loafing and high inequity of contribution, with strong leaders and strong laggards in the group. But when the same group members were installed around a table, their respective contributions to group performance appeared to be significantly better balanced. This result suggests that social loafing can be reduced simply by changing the spatial organization of group members. We observed this phenomenon in brainstorming tasks, but group structure may impact performance more generally (e.g., Abric, 1971). It was indeed shown that equity of contribution correlates to the collective intelligence of a group, a factor that explains groups' performance on a wide variety of tasks (Woolley et al., 2010). Our results suggest that groups may be more intelligent around a table.

The form factor is not the only advantage of interactive tabletop systems. Our experiments showed that the attractiveness of the technology and the digital interaction improved subjective experience and increased motivation to engage in the task (Buisine et al., 2012), which is also a moderating factor of social loafing (Brickner et al., 1986; Shepperd, 1993). Moreover, interactive tabletop systems are evaluated as funnier than pen-and-paper work around the table (Buisine et al., 2012) and this Fun factor may also contribute to increasing creativity (Barré et al., 2014).

Taking for granted that interactive tabletop is a valuable device to improve group brainstorming, we designed a series of tabletop interfaces to further enhance creative processes. For example, we introduced time pressure in brainstorming as a way to test the effect of the Press factor on creativity (Schmitt et al., 2012). In this experiment, the digital interface required brainstorming participants to enter an idea every 60, 30 or 15 seconds. We also considered time pressure as a support for group facilitation because, in line with Osborn's (1953) rules, it may force participants to give up evaluation and self-censorship. The results showed that time pressure increases fluency (number of ideas produced) and originality (number of unique ideas), but also deteriorated participants' satisfaction (Schmitt et al., 2012). This kind of artifact therefore requires careful assessment to be used in a safe way. In another interface design, we aimed to increase social comparison through the implementation of a graphical feedback. We placed in the center of the table a module showing in real time the number of ideas entered by each participant (in context in Fig. 1, in detail in Fig. 2). This feature proved to increase fluency (Fig. 3) as well as motivation (Schmitt et al., 2012).


Fig. 2: The graphical performance feedback in the center of the interface, showing in real time the number of ideas produced by each group member around the table.

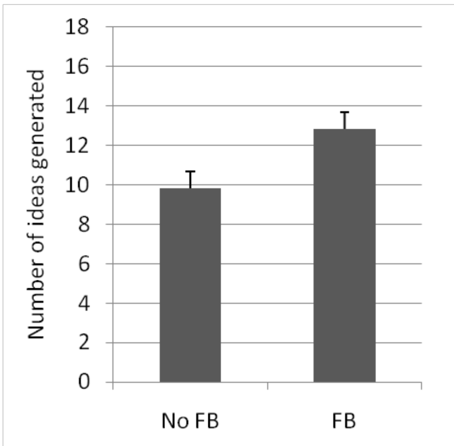


Fig. 3: Mean and standard error of the number of ideas produced by each participant without the performance feedback – No FB – or with the feedback – FB (Schmitt et al., 2012).

Finally, we designed an interface based on the SIAM theory – Search for Ideas in Associative Memory, (Nijstad & Stroebe, 2006). According to this theory, ideas in a brainstorming do not come one by one but rather in the form of *trains of thought*, which are rapid accumulations of semantically related ideas (Stroebe et al., 2010). Our interface enables brainstorming participants to visualize their associations of ideas and trains of thought (Fig. 4). This new interface proved to increase cognitive stimulation and originality of ideas: groups working with this interface produced more unique ideas (Fig. 5), less redundant ideas, and longer trains of thought (Afonso Jaco et al., 2014).


Fig. 4: The tabletop train-of-thought interface supporting visualization of association of ideas.

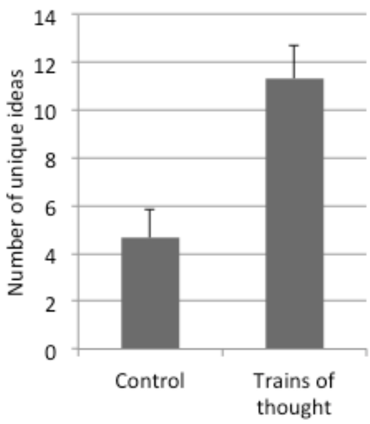


Fig. 5: Mean and standard error of the number of unique ideas generated with a control interface and with the Trains-of-thought interface (Afonso Jaco et al., 2014).

All in all, interactive tabletop proved to be a useful tool to support group brainstorming (Table 3): group facilitation, cognitive stimulation and social comparison are at least as effective as with electronic brainstorming, and our successive experiments showed that specific interface features such as performance feedback or visualization of trains of thought can further support the efficiency factors of group creativity. Interactive tabletop also highlighted Fun as an additional creativity booster. Moreover, this technology reduces social loafing through its around-the-table form factor and associated group awareness. However, several factors are difficult to handle around a table: first of all, group size is necessarily limited because of the form factor. A large group working around a large table or around two adjacent tables is tantamount to separating the group into several subgroups. Secondly, self-censorship remains difficult to manage around an interactive tabletop system: on the one side, the fun factor may be conducive to free wheeling and unleashed creativity. On the other side, increased group awareness and high identifiability of group members may enhance likelihood of self-censorship. Hence the effects of tabletop brainstorming on self-censorship remain unclear. Following this research program, we explored how alternative technologies could implement the best compromise between all these factors. In particular, a focus on self-censorship led us to consider the use of avatars in a virtual environment for supporting creativity.

| | | **Support provided by Interactive Tabletop Brainstorming** |
|---|---|---|
| **Efficiency factors for group creativity** | Group facilitation | ✔ |
| | Cognitive stimulation | ✔ |
| | Social comparison | ✔ |
| | Group size | ✗ |
| | Fun factor | ✔ |
| **Inefficiency factors for group creativity** | Production blocking | ✔ |
| | Social loafing | ✔ |
| | Self-censorship | ✗ |

Table 3: Effects of Interactive Tabletop Systems on efficiency and inefficiency factors of brainstorming.

## *Avatar-Mediated Brainstorming*

Avatars are digital characters representing users' identity in a virtual environment (Meadows, 2008). They are projections of users, or "tangible embodiment of their identity" (Yee et al. 2009). Through avatars, users can experience multiple identities or highlight certain aspects of their ideal self (Bessière et al. 2007). Thereby, avatars allow users to change their appearance, their social roles, and their identity in a virtual world. A recent line of research has also shown that users' behaviors are influenced congruently to their avatar's identity. This behavioral modulation was named *Proteus effect* (Yee and Bailenson 2007, 2009) after the Greek God Proteus who possessed the ability of metamorphosis.

On a theoretical viewpoint, this phenomenon could be explained through the seminal proposals of self-perception theory (Bem, 1972), according to which individuals explain their attitudes and internal states based on observation of external cues, just as an external observer would. This is why a change in self-representation may lead to a change in behavior. Moreover, in situations of anonymity and deindividuation (Postmes and Spears, 1998) like in a virtual world, self-perception reliance on identity cues (and therefore on avatar's appearance) is enhanced (see Yee et al., 2009).

The Proteus effect was observed in several contexts: for example, attractive avatars lead to behave in a more intimate way in terms of self-disclosure and interpersonal distance (Yee and Bailenson, 2007), and tall avatars lead to more confident behavior in a negotiation task (Yee and Bailenson, 2007; Yee et al., 2009). It was also shown that the Proteus effect endures over time and affects subsequent offline behavior (Yee et al., 2009; Rosenberg et al., 2013; Yoon and Vargas, 2014). This means that the appearance of an avatar influences users' behavior not only in the virtual world, but also in the real world. Likewise, can avatars be used to increase creativity?

In this series of experiments, we used avatars to modify self-perception in order to improve one’s creative performance. To do so, the first step was to identify what kind of avatars would be likely to increase the perception of one’s creative skills. These experiments being conducted with engineering students, we studied the cognitive representation of creativity in this population. This led us to identify the concept of the Inventor as a common relevant creative figure for engineers (Guegan et al., 2016). Accordingly, we designed and validated avatars featuring characteristics of inventors (e.g. looking like Einstein, wearing a lab coat or using scientist’s instruments, Fig. 6). We expected that users of these avatars, observing their digital appearance (“I embody an inventor”), would make implicit inferences about their creative skills (“I am creative”) and improve their creative performance (“I have a lot of ideas / good ideas”). Consistently, our results show that engineering students using inventor avatars during a virtual brainstorming session perform significantly higher in fluency and originality in comparison to students using neutral avatars and students in a face-to-face electronic brainstorming situation (Guegan et al., 2016). Moreover, this benefit endured over time since participants allocated to inventor condition continued to perform higher in a subsequent face-to-face brainstorming (Session 2, see Fig. 7). Subjective data also showed that brainstorming in a virtual environment (either with a neutral or a creative avatar) was rated as funnier than electronic brainstorming system.

Fig. 6: Example of an avatar perceived as an Inventor.

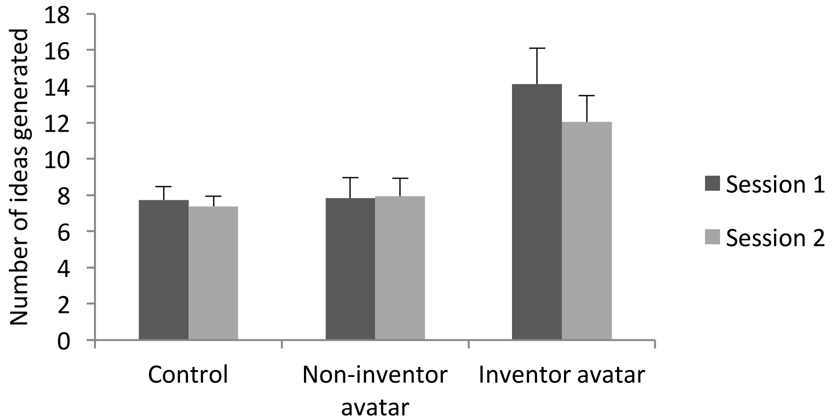


Fig. 7: Mean and standard error of the number of ideas generated by each participant as a function of the condition (control face-to-face, neutral avatar and inventor avatar) and the session (Guegan et al., 2016).

The previous experiment managed to increase creativity by making engineers identify with the figure of the inventor. In terms of innovation process, this is likely to emphasize engineers' talent to develop products of superior technological value and therefore support a Technology-Driver strategy (Jaruzelski et al., 2014) representing high degrees of R&D difficulty (Mantelet et al., 2016). Then we wondered whether avatars could be used to help engineers develop User-Centered innovations, motivated by customer needs instead of technological value. To investigate this question, we designed a case study with a major company from the transportation industry. A group of highly qualified employees from the innovation department were attributed inventor avatars like in the previous experiment, and another group was attributed avatars representing users of public transportation (Persona avatars, e.g. a mother with a newborn, a child, an elderly person, a train manager). Both groups were immersed in a transportation situation (metro tour across a virtual Paris, Fig. 8) and had to find applications for smart windows in public transportation. As expected, the content of ideas was influenced congruently to avatars' appearance: the inventor condition led to a techno-centered ideation profile, oriented toward technological solutions, while the Persona condition led to more user-centered, needs-oriented ideas (Buisine et al., 2016). Consistently, inventors' production tended to be better evaluated through industrial criteria and Personas' production tended to be better evaluated by transportation users. These results suggest that avatar-mediated brainstorming could be a powerful tool enabling innovation team to align ideation to their strategy (e.g. technology-centered or user-centered).

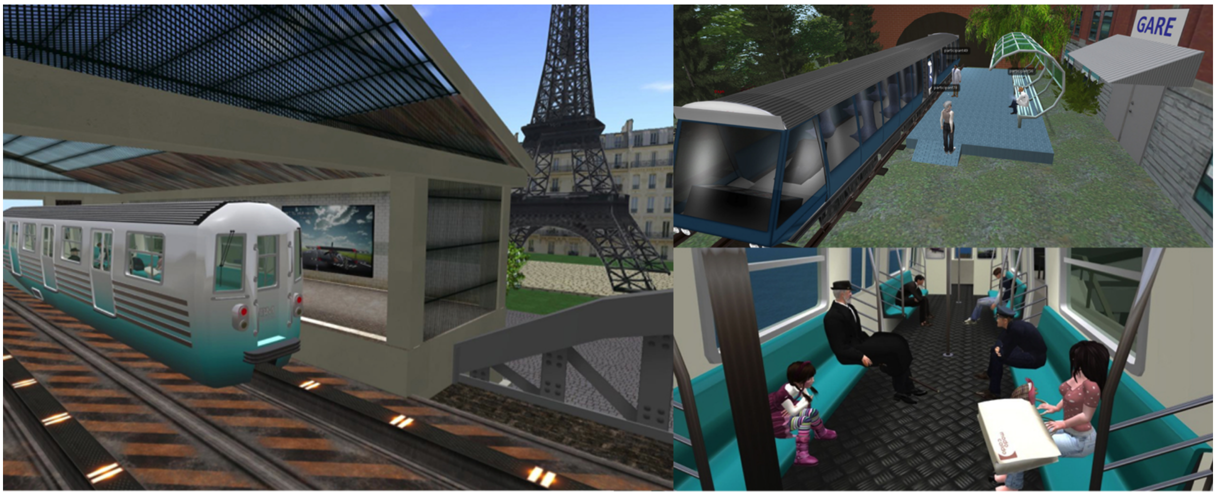


Fig. 8: Example of virtual environment and avatars used in a brainstorming session about public transportation.

Beyond self-perception and personal identity, avatars may also be a convenient medium to emphasize social identity in a virtual environment (e.g., Guegan et al., 2015). Social identity is defined as a part of self-concept linked to group membership (Tajfel &Turner, 1979). In this way, a positive evaluation of one's in-group may contribute to a positive evaluation of the self, leading people to work as a group and for the group and exhibit increased performance (i.e., *social laboring*, Haslam, 2004). Hence in a subsequent experiment, we introduced social identity cues on avatars' clothes as it could be implemented in various professional contexts (e.g. clothes in the colors and logo of a company, sport team jerseys). On the basis of the Social Identity Model of Deindividuation Effects (Reicher, Spears, & Postmes, 1995; Spears & Lea, 1994, 1992), we assumed that virtual cues would exert a positive effect on group performance (see Tanis & Postmes, 2008). By perceiving themselves as members of a group rather than co-workers who are "gathered together", individuals should be more likely to engage in online collaborative work. The results confirmed this assumption by showing that social identity cues on avatars' clothes increased both group identification and creative performance (Fig. 9; Guegan et al., submitted). Hence avatars appeared as a valuable tool to reduce social loafing and support teamwork in a meaningful way. Moreover, in the context of a creative assignment, group identification may influence not only the perception of group members ("we" instead of "I"), but also of their ideas ("our production" instead of "my production"). Because attention to others' ideas is key to creativity (Paulus & Brown, 2007; Michinov, 2012), increasing the salience of social identity may also improve cognitive stimulation.

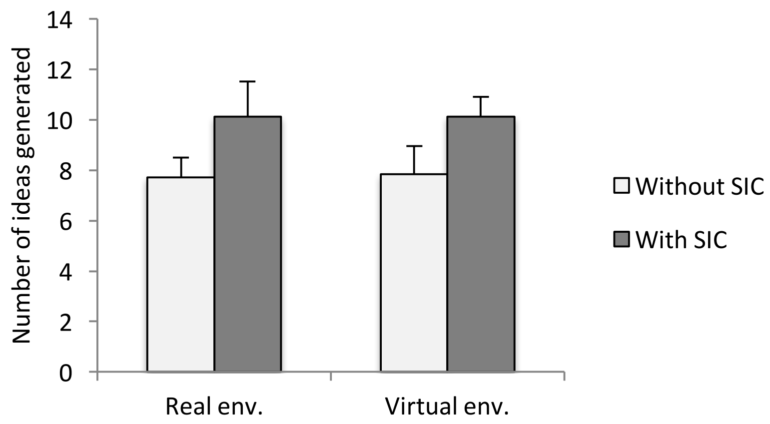


Fig. 9: Mean and standard error of the number of ideas generated by each participant with and without Social Identity Cues (SIC), in the real and virtual environment (Guegan et al., submitted).

To sum up, the use of avatars may provide multiple benefits in the context of group brainstorming (Table 4): group facilitation is similar to electronic brainstorming system and can be conducted remotely through the instant messaging tool of the virtual platform. The facilitator can be represented by an avatar like all participants, or can manage the group without being embodied or materialized in the virtual world. Classical efficiency factors such as cognitive stimulation and social comparison are supported and can be further enhanced with relevant avatars' appearance. Moreover, virtual sessions were repeatedly evaluated as fun in all our experiments, which may contribute to foster engagement and creativity. Virtual brainstorming can also involve large groups to promote diversity of views and increase cognitive stimulation. There is potentially no limit to group size in a virtual world. Idea generation is still performed through the written channel to avoid production blocking and improve attention to others' ideas. Finally, avatars provide a unique means to stimulate creativity through modifications of individuals' perception of their personal and/or social identity, thereby reducing social loafing and self-censorship to help everyone reveal his/her best creative potential.

| | | **Support provided by Avatar-Mediated Brainstorming** |
|---|---|---|
| **Efficiency factors for group creativity** | Group facilitation | ✔ |
| | Cognitive stimulation | ✔ |
| | Social comparison | ✔ |
| | Group size | ✔ |
| | Fun factor | ✔ |
| **Inefficiency factors for group creativity** | Production blocking | ✔ |
| | Social loafing | ✔ |
| | Self-censorship | ✔ |

Table 4: Effects of avatars on efficiency and inefficiency factors of brainstorming.

## Conclusion

New technologies, when mastered and used wisely, may provide unsuspected support to socio-cognitive processes. In this chapter, we focused on collective creativity and analyzed how several technologies interact with its processes. This research program enabled us to better understand the potentials of the technologies, sometimes to contribute to specify them and design new tools, and above all to gain new knowledge on how group creativity works, and how to increase its performance.

For several decades, the brainstorming method has helped many teams to structure their creative endeavors and has provided a framework to study collective creativity for many researchers throughout the world. As soon as in the 80's, electronic brainstorming systems were used to share and capitalize ideas in large groups, sometimes in co-presence, sometimes remotely, and even asynchronously. Effective in many respects, this tool was nonetheless pointed out to be detrimental to group membership and sense of belonging, which is a source of social loafing and lower engagement in the creative task.

To combine the advantages of a digital platform and of a convivial setting, we studied the use of interactive tabletop systems for brainstorming around the table and rebuilding group awareness. This research led us to better understand the importance of social and motivational factors in group creativity and inspired us the design of several original interfaces to optimize production, sharing and visualization of ideas. However, the reliance on synchronous collocated collaboration paradigm might appear as a limitation of this technology for group creativity. Companies seeking to develop their teams' creativity also need flexible tools supporting remote collaboration. Hence the challenge emerged to find a tool supporting remote collaboration and group identification at the same time.

Such a tool was found in the form of avatar-mediated brainstorming and gave rise to a series of experiments confirming the potential of this technology. Avatars have the advantage of triggering self-perception mechanisms that may positively impact creative processes in multiple ways: anonymity and the use of carefully chosen avatars may reduce self-censorship and social loafing, to the benefit of creative performance and innovation strategies of companies. Avatars sharing social identity cues can help group members focus on team's issues and challenges, and create social laboring. They can also be used to infuse new dynamics, promote a new viewpoint and change routines (e.g. hierarchical asymmetry, interpersonal relations, leadership) among regular coworkers. All these factors seem likely to help individuals develop their creativity and support innovation processes in organizations.

## References


Abric, J. C. (1971). Experimental study of group creativity: Task representation, group structure, and performance. *European Journal of Social Psychology*, *1*(3), 311-326.

Afonso Jaco, A., Buisine, S., Barré, J., Aoussat, A., & Vernier, F. (2014). Trains of thought on the tabletop: Visualizing association of ideas improves creativity. *Personal and Ubiquitous Computing*, 18, 1159-1167.

Barré, J., Buisine, S., Guegan, J., & Aoussat, A. (2014). Le caractère ludique comme levier de performance pour l'anticipation des besoins des utilisateurs. In Proceedings of ErgoIA 2014 Colloque francophone sur l'Ergonomie et l'Informatique Avancée, 25-32.

Bartis, S., Szymanski, K., & Harkins, S.G. (1988). Evaluation and performance: a two-edged knife. *Personality and Social Psychology Bulletin*, 14, 242–251.

Bem, D. (1972). Self perception theory. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (vol. 6). New York: Academic Press.

Bessière, K., Seay, A. F., & Kiesler, S. (2007). The ideal elf: Identity exploration in World of Warcraft. *CyberPsychology and Behavior*, 10(4), 530-535.

Brickner, M.A., Harkins, S.G., & Ostrom, T.M. (1986). Effects of personal involvement: thought-provoking implications for social loafing. *Journal of Personality and Social Psychology*, 51, 763–769.
Buisine, S., Besacier, G., Aoussat, A., & Vernier, F. (2012). How do interactive tabletop systems influence collaboration? *Computers in Human Behavior*, 28, 49-59.
Buisine, S., Guegan, J., Barré, J., Segonds, F., & Aoussat, A. (in press). Using avatars to tailor ideation process to innovation strategy. *Cognition, Technology & Work*.
Dennis, A.R., & Valacich, J.S. (1993). Computer brainstorms: More heads are better than one. *Journal of Applied Psychology*, 78(4), 531–537.
Dennis, A.R., & Williams, M.L. (2002). *Electronic brainstorming: Theory, research and future directions*. Kelley School of Business, Technical Reports TR116-1.
DeRosa, D.M., Smith, C.L., & Hantula, D.A. (2007). The medium matters: Mining the long-promised merit of group interaction in creative idea generation tasks in a meta-analysis of the electronic group brainstorming literature. *Computers in Human Behavior*, 23, 1549–1581.
Diehl, M., & Stroebe, W. (1987). Productivity loss in brainstorming groups: Toward the solution of a riddle. *Journal of Personality and Social Psychology*, 53(3), 497–509.
Dugosh, K. L., & Paulus, P. B. (2005). Cognitive and social comparison processes in brainstorming. *Journal of Experimental Social Psychology*, 41, 313–320.
Dugosh, K. L., Paulus, P. B., Roland, E. J., & Yang, H. C. (2000). Cognitive stimulation in brainstorming. *Journal of Personality and Social Psychology*, 79(5), 722–735.
Gallupe, R.B., Bastianutti, L.M., & Cooper, W.H. (1991). Unblocking brainstorms. *Journal of Applied Psychology*, 76(1), 137–142.
Gallupe, R.B., Cooper, W.H., Grisé, M.L., & Bastianutti, L.M. (1994). Blocking electronic brainstorms. *Journal of Applied Psychology*, 79(1), 77–86.
Guegan, J., Moliner, P., & Buisine, S. (2015). Why are online games so self-involving: A social identity analysis of massively multiplayer online role-playing games. *European Journal of Social Psychology*, *45*(3), 349-355.
Guegan, J., Buisine, S., Mantelet, F., Maranzana, N., & Segonds, F. (2016). Avatar-mediated creativity: When embodying inventors makes engineers more creative. *Computers in Human Behavior*, 61, 165-175.
Guegan, J., Segonds, F., Barré, J., Maranzana, N., Mantelet, F. & Buisine, S. (submitted). Social identity cues to improve avatar-mediated creativity in group. *Journal of Computer-Mediated Communication*.
Harkins, S.G., & Jackson, J.M. (1985). The role of evaluation in eliminating social loafing. *Personality and Social Psychology Bulletin*, 11(4), 457–465.
Harkins, S.G., & Szymanski, K. (1988). Social loafing and self-evaluation with an objective standard. *Journal of Experimental Social Psychology*, 24, 354–365.
Haslam, S.A. (2004). *Psychology in Organizations: The Social Identity Approach*. London: Sage.
Heslin, P.A. (2009). Better than brainstorming? Potential boundary conditions to brainwriting for idea generation in organizations. *Journal of Occupational and Organizational Psychology*, 82, 129–145.
Jaruzelski, B., Staack, V., & Goehle, B. (2014). Proven paths to innovation success. *Strategy + Business*, 77, 2–16.
Karau, S.J., & Hart, J.W. (1998). Group cohesiveness and social loafing: effect of a social interaction manipulation on individual motivation within groups. *Group Dynamics: Theory, Research, and Practice*, 2, 185–191.
Karau, S.J., & Williams, K.D. (1993). Social loafing: a meta-analytic review and theoretical integration. *Journal of Personality and Social Psychology*, 65, 681–706.
Kerr, D.S., & Murthy, U.S. (2004). Divergent and convergent idea generation in teams: A comparison of computer-mediated and face-to-face communication. *Group Decision and Negotiation*, 13, 381–399.

Kramer, T.J., Fleming, G.P., & Mannis, S.M. (2001). Improving face-to-face brainstorming through modeling and facilitation. *Small Group Research,* 32, 533–557.

Mantelet, F., Segonds, F., Maranzana, N., Guegan, J., & Buisine, S. (2016). Virtual environment in the early design phases: how to be more creative? International Virtual Concept Workshop on ''Major Trends in Product Design''.

McKinlay, A., Procter, R., & Dunnett, A. (1999). An investigation of social loafing and social compensation in computer-supported cooperative work. In Proceedings of GROUP'99 International Conference on Supporting Group Work, ACM Press, 249–257.

Meadows, M.S. (2008). *I, Avatar: the culture and consequences of having a second life*. Berkley: New Riders.

Michinov, N. (2012). Is electronic brainstorming or brainwriting the best way to improve creative performance in groups? An overlooked comparison of two idea-generation techniques. *Journal of Applied Social Psychology*, 42(S1), E222-E243.

Michinov, N. & Primois, C. (2005). Improving productivity and creativity in online groups through social comparison process: new evidence for asynchronous electronic brainstorming. *Computers in Human Behavior*, 21, 11–28.

Nijstad, B. A., Stroebe, W., & Lodewijkx, H. F. M. (2002). Cognitive stimulation and interference in groups: Exposure effects in an idea generation task. *Journal of Experimental Social Psychology*, 38, 535–544.

Nijstad, B. A., Stroebe, W., & Lodewijkx, H. F. M. (2003). Production blocking and idea generation: Does blocking interfere with cognitive processes? *Journal of Experimental Social Psychology*, 39, 531–548.

Nijstad, B.A., & Stroebe, W. (2006). How the group affects the mind: a cognitive model of idea generation in groups. *Personality and Social Psychology Review*, 10, 186–213.

Nunamaker, J. F., Dennis, A. R., Valacich, J. S., Vogel, D., & George, J. F. (1991). Electronic meeting systems. *Communications of the ACM*, 34(7), 40-61.

Offner, A.K., Kramer, T.J., & Winter, J.P. (1996). The effects of facilitation, recording, and pauses on group brainstorming. *Small Group Research,* 27, 283–298.

Osborn, A. F. (1953). *Applied imagination. Principles and procedures of creative problem-solving*. Charles Scribner's Sons.

Oxley, N.L., Dzindolet, M.T., & Paulus, P.B. (1996). The effects of facilitators on the performance of brainstorming groups. *Journal of Social Behavior and Personality,* 11(4), 633–646.

Parnes, S.J., & Meadow, A. (1959). Effects of ”brainstorming” instructions on creative problem solving by trained and untrained subjects. *Journal of Educational Psychology,* 80(4), 171–176.

Paulus, P.B., Kohn, N.W., Arditti, L.E., & Korde, R.M. (2013). Understanding the group size effect in electronic brainstorming. *Small Group Research*, 44, 332–352.

Paulus, P.B., & Dzindolet, M.T. (1993). Social influence processes in group brainstorming. *Journal of Personality and Social Psychology*, 64(4), 575–586.

Paulus, P.B., & Yang, H.C. (2000). Idea generation in groups: a basis for creativity in organizations. *Organizational Behavior and Human Decision Processes*, 82, 76–87.

Paulus, P.B., & Brown, V.R. (2007). Toward more creative and innovative group idea generation: a cognitive-social-motivational perspective of brainstorming. *Social and Personality Psychology Compass*, 1(1), 248-265.

Paulus, P.B., Nakui, T., Putman, V.L., & Brown, V.R. (2006). Effects of task instructions and brief breaks on brainstorming. *Group Dynamics: Theory, Research, and Practice,* 10(3), 206–219.

Postmes, T., & Spears, R. (1998). Deindividuation and anti-normative behavior: a meta-analysis. *Psychological Bulletin*, 123, 238-259.

Reicher, S. D., Spears, R., & Postmes, T. (1995). A social identity model of deindividuation phenomenon. *European Review of Social Psychology*, 6, 161–198.

Rosenberg, R. S., Baughman, S. L., & Bailenson, J. (2013). Virtual superheroes: using superpowers in virtual reality to encourage prosocial behavior. *PloS one*, 8(1).

Schmitt, L., Buisine, S., Chaboissier, J., Aoussat, A., & Vernier, F. (2012). Dynamic tabletop interfaces for increasing creativity. *Computers in Human Behavior*, 28, 1892-1901.

Serva, M.A., & Fuller, M.A. (1997). Preventing social loafing in the collaborative technology classroom. In Proceedings of SIGCPR'97 Computer Personnel Research Conference, ACM Press, 84–86.

Shen, C., Ryall, K., Forlines, C., Esenther, A., Vernier, F., Everitt, K., Wu, M., Wigdor, D., Ringel Morris, M., Hancock, M., & Tse, E. (2006) Informing the design of direct-touch tabletops. *IEEE Computer Graphics and Applications*, 26, 56–66.

Shepperd, J.A. (1993). Productivity loss in performance groups: a motivation analysis. *Psychological Bulletin*, 113, 67–81.

Spears, R., & Lea, M. (1992). Social influence and the influence of the “social” in computer-mediated communication. In M. Lea (Ed.), *Contexts of computer-mediated communication* (pp. 30–65). London: HarvesterWheatsheaf.

Spears, R., & Lea, M. (1994). Panacea or Panopticon? The hidden power in computer-mediated communication. *Communication Research*, 21, 427–459.

Stroebe, W., Nijstad, B.A., Rietzschel, E.F. (2010). Beyond productivity loss in brainstorming groups: the evolution of a question. In: M.P. Zanna, & J.M. Olson (Eds). *Advances in experimental social psychology*, 43, 157–203. New York: Academic Press.

Tajfel, H., & Turner, J. C. (1979). An integrative theory of intergroup conflict. In W. G. Austin & S. Worchel (Eds.), *The social psychology of intergroup relation*. Monterey, CA: Brooks/Cole.

Tanis, M., & Postmes, T. (2008). Cues to identity in online dyads: Effects of interpersonal versus intragroup perceptions on performance. *Group Dynamics: Theory, Research, and Practice*, 12(2), 96.

Turner, W.M., & Rains, J.D.: (1965) Differential effects of ”brainstorming” instructions upon high and low creative subjects. *Psychological Reports,* 17, 753–754.

Valacich, J.S., Dennis, A.R., Connolly, T. (1994). Idea generation in computer-based groups: A new ending to an old story. *Organizational Behavior and Human Decision Processes*, 57, 448–467.

Weisskopf-Joelson, E., & Eliseo, T.S. (1961). An experimental study of the effectiveness of brainstorming. *Journal of Applied Psychology,* 45(1), 45–49.

Williams, S. D. (2002). Self-esteem and the self-censorship of creative ideas. *Personnel Review*, 31(4), 495-503.

Williams, K.D., & Karau, S.J. (1991). Social loafing and social compensation: The effects of expectations of co-worker performance. *Journal of Personality and Social Psychology*, 61(4), 570-581.

Woolley, A. N., Chabris, C. F., Pentland, A., Hashmi, N., & Malone, T. W. (2010). Evidence for a collective intelligence factor in the performance of human groups. *Science*, 330, 686–688.

Yee, N., & Bailenson, J. (2007). The Proteus effect: the effect of transformed self-representation on behavior. *Human Communication Research*, 33, 271-290.

Yee, N., & Bailenson, J. (2009). The difference between being and seeing: the relative contribution of self-perception and priming to behavioral changes via digital self-representation. *Media Psychology*, 12(2), 195-209.

Yee, N., Bailenson, J., & Ducheneaut, N. (2009). The Proteus effect: implications of transformed digital self-representation on online and offline behavior. *Communication Research*, 36(2), 285-312.

Yoon, G., & Vargas, P. T. (2014). Know thy avatar the unintended effect of virtual-self representation on behavior. *Psychological Science*, 25(4), 1043-1045.

## Authors' biographies

**Stéphanie Buisine** is a Professor in Innovation at EI.CESI school of engineering in Paris-Nanterre (LINEACT), and associate member of Paris-Descartes University (LATI). Her multidisciplinary background includes Psychology, Ergonomics, Human-Computer Interaction and Industrial Engineering. Her research focuses on the methodological, technological and organizational factors of innovation, with a special emphasis on need-seeker strategy, prospective methods, technology-supported creativity, and innovation culture.

**Jérôme Guegan** is an Associate professor in Social Psychology at Paris-Descartes University (LATI). His research focuses on group processes, social identity and creativity in computer-mediated communication. He notably studied the influence of avatars (digital self-representations) and the characteristics of virtual environments on the creative process.

**Frédéric Vernier** is an Associate professor in Computer Science at University Paris-Sud (LIMSI-CNRS). He leads research activities in the field of Human Computer Interaction and studies the novel paradigm of tabletop interfaces. Tabletop differs from traditional desktop-based interfaces because they are aimed to collaborative usage, fingers/hands differ from computer mice and horizontal setting create multiple orientations for users point of view and documents. Frederic proposed numerous interaction techniques and visualization schemes to overcome tabletop limitations and unlock the potential of a shared horizontal surface of interaction.