Embodied Creative Agents: A Preliminary Social-Cognitive Framework

Stéphanie Buisine[1,*], Améziane Aoussat[1], and Jean-Claude Martin[2]

[1] ENSAM-LCPI, 151 bd de l'Hôpital, 75013 Paris, France
stephanie.buisine@paris.ensam.fr
[2] LIMSI-CNRS, BP 133, 91403 Orsay Cedex, France

Abstract. The goal of this paper is to open discussion about industrial creativity as a potential application field for Embodied Conversational Agents. We introduce the domain of creativity and especially focus on a collective creativity tool, the brainstorming: we present the related research in Psychology which has identified several key cognitive and social mechanisms that influence brainstorming process and outcome. However, some dimensions remain unexplored, such as the influence of the partners' personality or the facilitator's personality on idea generation. We propose to explore these issues, among others, using Embodied Conversational Agents. The idea seems original given that Embodied Agents were never included into brainstorming computer tools. We draw some hypotheses and a research program, and conclude on the potential benefits for the knowledge on creativity process on the one hand, and for the field of Embodied Conversational Agents on the other hand.

Keywords: Embodied Conversational Agents, Creativity, Brainstorming, Facilitator, Expressivity, Personality.

1 Introduction

This paper presents a potential application field for Embodied Conversational Agents (ECAs) which has not been explored yet, namely the field of industrial creativity and computer-supported brainstorming. The paper is structured as follows: in section 2 we define the field of industrial creativity, and expose the brainstorming process and state of the art. In section 3 we show that ECAs were never included in the existing creativity-supporting tools although they would raise interesting research questions. We elaborate on several examples of hypotheses and present the related research program. We expose the expected benefits of such a research program for both fields of industrial creativity and ECA design, before concluding on our general iterative approach between a social-cognitive framework of creativity and experimental investigations.

* Corresponding author.

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2 Industrial Creativity

2.1 Scope Definition

Creativity is a high-level cognitive process which has given rise to researches in various fields such as Psychology [14, 63], Engineering [6, 33, 50, 68] or Human-Computer Interaction [12, 24, 61, 62]. Creativity applies to artistic work (e.g. fine arts, literature, architecture, music), educative domain (e.g. early-learning and playing activities), scientific skills (e.g. problem resolution, discoveries, epistemological breakthroughs), and industrial applications (e.g. creation of product functions, stylistic design of artifacts).

In this paper we consider creativity in industrial applications, for example when some people design products that contribute to changing our everyday habits with new technologies or innovative functions (e.g. global positioning systems in cars to find one's way, or in mobile phones to be easily located, portable players radically changing our relations to our multimedia contents, etc.). Understanding and supporting this kind of creativity is not only an interesting research challenge: industrial innovation being one of the few ways for western countries to remain competitive, the product life cycle is getting shorter and shorter and new products have to be constantly developed and timely placed to market.

2.2 Brainstorming

Group Creativity. To improve creativity, a wide-spread practice in companies is the group brainstorming. Although creativity fundamentally remains an individual capacity, many collective creativity phenomena were demonstrated. For example, cognitive stimulation (i.e. the exposition to others' ideas) proved to enhance idea generation in individuals [21, 22, 45]. Moreover, social comparison (i.e. the possibility to compare one's own performance to the others') was shown to be motivating for brainstorming participants and to improve idea generation [2, 32, 38, 43, 53]. Therefore creativity appears worth implementing in groups, for example in the form of a brainstorming. This is especially true for industrial creativity which can benefit from multiple, or even multidisciplinary viewpoints [8].

The Brainstorming Method. Although brainstorming is sometimes practiced wildly, some methodological toolkits [33, 50, 68] have been formalized to structure the reflection and manage groups' dynamics. For example, the preparation (e.g. decomposing the problem, formulating the questions to address) is fundamental to the quality of outcome from the session. Besides, for efficient idea generation and a smooth running of the group, Osborn [50] recommends stating and displaying the following rules during the whole course of the session: *Criticism is ruled out; Free-wheeling is welcomed; Quantity is wanted; Combination and improvement are sought*. These rules need to be formalized and periodically reminded to the brainstorming participants because such attitudes are not spontaneous, and the use of Osborn's rules actually proved to enhance brainstorming productivity [52, 54, 65, 71]. The brainstorming is also more efficient when leaded by a "facilitator", i.e. someone who does not participate in the idea generation but manages speech turns, encourages the participants individually and collectively, ensures that the focus on the problem and the brainstorming rules are kept observed [36, 49, 50, 51, 54]. Today, being a facilitator can be a full-time occupation since many consulting services specialized in creative problem solving were set up to assist companies in their conducting of creativity sessions.

Electronic Brainstorming. A major shortcoming of classical brainstorming sessions as previously defined is the absolute necessity of managing speech turns: each participant has to wait for her/his turn to give an idea and can give only one idea within a turn. However, it was demonstrated that ideas do not come one by one but rather by "trains of thought" (i.e. by automatic and rapid accumulations of semantically related ideas [46]). Verbal brainstorming therefore interferes with idea generation process in several ways: due to the coordination needs and time constraints, the participants have to rehearse some of their ideas, which stops further idea generation and prevents them from listening to the ideas of others, or they select the ideas they will give to the group (which implies a self-censorship that should normally be ruled out). These phenomena occurring during verbal brainstorming are referred to as "production blocking" [19, 43, 46].

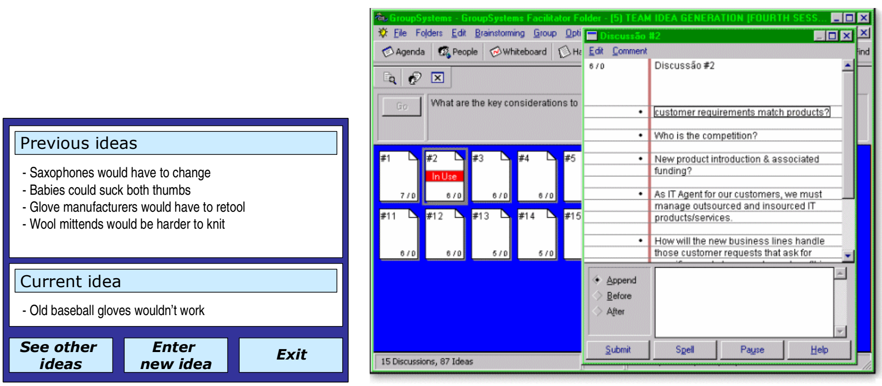

Fig. 1. Examples of collective electronic brainstorming systems: On the left panel, a research tool adapted from Gallupe et al. [27], here used in the Thumbs Problem (a classical problem in brainstorming research about the practical benefits or difficulties that would arise if everyone had an extra thumb on each hand). On the right panel, the commercial software GroupSystems I (www.groupsupport.com).

To counteract production blocking while keeping the advantages of group brainstorming (e.g. the positive effects of cognitive stimulation and social comparison), electronic brainstorming procedures were created. They consist in making the participants simultaneously generate ideas on individual computers networked together and located in the same room [17]. The ideas typed in by the participants are displayed on a large-screen in the front of the room, as well as on each workstation (Fig. 1). The role of the facilitator is the same as in traditional brainstorming except that s/he does not have to manage speech turns. In the field of

Computer-Supported Cooperative Work (CSCW), electronic brainstorming tools fall into the category of group decision systems and electronic meeting rooms [23]. They are rather simple systems relative to other co-located or distant groupware, and the context of creativity does not suppose any special needs.

Electronic brainstorming were shown to actually improve idea production in comparison to control brainstorming sessions [16, 27, 28, 34, 42, 58, 66], and this benefit increases with group size [17, 18].

Personality Issues in Brainstorming. Beside modeling general brainstorming mechanisms applying to all groups whatever their composition, many researchers examined the influence of participants' personality on idea generation and creativity [5, 7, 11, 25, 26, 31, 56]. The close analysis of these results is beyond the scope of the present paper but we may mention for example that the following personality traits were shown to influence creativity: psychoticism, social anxiety, openness, impulsivity, individualism, extroversion, etc.

The previous studies all concerned participants' personality. Likewise, we may wonder whether facilitator's personality would also influence idea production from the brainstorming participants. However, to our knowledge, this issue has never been investigated. Although the usefulness of facilitators was confirmed [36, 49, 51, 54], their behavior and recommended personality was always kept constant. A good facilitator is expected to always stay neutral, to express professionalism and self-confidence, to be dynamic and demonstrate great communication and listening skills, to be friendly and show a sense of humor [20, 70]. What if the facilitator was more emotionally involved in her/his relation to the group? What if s/he showed extreme sympathy or, conversely, disagreeableness? The question is not straightforward since participant's creativity is likely to be triggered off by both positive feelings (through e.g. social facilitation or the experience of positive affects [10]) and negative feelings (because it is fundamentally an adaptive capacity for solving problems in contexts of fear, discomfort, aggression, competition, etc. [50]).

3 How Can Embodied Agents Help?

The possibility to employ Embodied Conversational Agents (ECAs) in electronic brainstorming interfaces is never evoked in the previous state of the art. Yet, some of those systems originally designed to be used in a co-located setup have evolved to applications for distant asynchronous brainstorming through the Internet [17, 43]. But the interface of these systems was never embodied.

The same observation applies more generally in the broad field of computer-supported creativity. Corporate needs for creativity gave rise to a market for computational tools of creativity and a lot of research prototypes and commercial software have been developed[1]. According to Shneiderman [61], the existing computer solutions can be categorized into three approaches: inspirational tools (e.g. favoring visualization, free association, or sources of inspiration), structural tools (e.g. databases, simulations, methodical techniques of reasoning), and situational tools (e.g.

[1] Examples of commercial software include Goldfire Innovator (www.invention-machine.com), ThoughtOffice (www.ideacenter.com), MindManager (www.mindjet.com).

based on the social context, enabling peer-consultation, or dissemination). Lubart [39] adopted a classification grounded on the role played by the computer in the creative process: systems assisting the user in the management of creative projects (computer as nanny), those supporting communication and collaboration within a team (computer as pen-pal), systems implementing creativity enhancement techniques (computer as coach) and those contributing to the idea production (computer as colleague). But these roles were never personified and such a possibility is never mentioned is the literature related to creativity-assisting tools.

Likewise in the field of ECAs, industrial creativity was never studied as a potential application framework. ECAs are used in contexts of games, education, personal assistance, commercial websites, etc. The domain closest to creativity may be the use of ECAs as partners of storytelling for children [13, 59].

3.1 Hypotheses

The idea to integrate ECAs into creativity-supporting tools, and especially into brainstorming tools, seems relevant for several reasons we develop in the following paragraphs.

Personification. Personifying the interface can be interesting in itself, as it was shown with pedagogical agents whose presence can be sufficient to improve subjective experience and also sometimes performance [3, 44, 67]. Therefore it could be interesting to investigate whether this kind of effect would also arise for a creativity application in which either the brainstorming participants or the facilitator are represented by ECAs.

Dialog. The domain of ECAs is still considered as lacking believability because current technologies of artificial intelligence do not meet users' requirements in terms of dialog. But in the field of creativity, especially if the ECA represents a partner in the brainstorming, such a weakness can become a strength [39]. Indeed the contribution of ECAs would not rely on exact reasoning but could be related to suggesting new ways for idea searching, to diverging by associative thinking, using e.g. databases and semantic networks. In such a context, a weird idea association made by an ECA could be useful and efficient; in fact, an artificial diverging agent was previously implemented in a brainstorming system [47], but this agent was not personified. Therefore we assume that the effect of interface personification could be tested without being biased by ECA's poor reasoning capacities.

This argument applies for a partner ECA but not for a facilitator ECA, who would have to understand all the interaction and react adequately and timely. In this case the solution could be to include an ECA and a model of nonverbal behavior into the system and control the verbal behavior by a wizard-of-oz setup.

Expressivity, Personality, Role-Playing. A major research interest in ECA community concerns agents' capacity to mimic human affective behaviors [4, 9, 15, 40] and personality expression (with e.g. the adaptation of FFM and OCC personality models [1]). ECA personalities can be used to control the expression of emotion (intensity or modalities), to represent the importance of goals, or to modify the probability of occurrence of certain behaviors [69]. The interrelations between emotions, mood and personality are especially focused on [57, 64]: for example some models of personality featuring several interdependent layers with different timescales were proposed [29, 37]. The final goal of such research is to endow virtual characters with individual personalities [41, 60]: how different characters cope differently with emotions, which weights they use for evaluating events, etc. Gesture style dictionaries [48] and character profiles [30] were also studied.

Some of these expressive agents were included into teams of ECAs in which each one has his role (see Rist et al. [55] for a review): for example, the eShowroom generates commercials by using several presentation agents with different roles, different attitudes towards the product, different personality traits, etc. Pedagogical applications were also designed with teams of ECAs [35] representing different instructional roles such as the expert, the tutor, the mentor, the motivator, the learning companion (or peer tutee), the helper, the competitor, the troublemaker, etc. Sometimes human users can join the team as in multi-party gatherings and conversations in virtual space: for example the Magic Monitor [55] is a multi-user conferencing system in which ECAs represent the conversation partners, be they humans or virtual conversational agents, and the system includes a virtual facilitator agent who provides meta-information about the conversation. Some recent online games[2] are also built on a similar architecture: the players choose their character, collaborate together with other players and with virtual agents towards the achievement of a common goal.

In the context of creativity sessions, there are only two roles (potentially associated with multiple personality dimensions): the partner and the facilitator. A few studies examined the influence of group members' personality on the creativity of their partners, showing e.g. that the presence of social anxious people in a group made their partners spontaneously lower their performance [11]. However, personality research has been concerned mainly with the relation between individuals' personality and their own creativity, and the influence of the facilitator's personality was never tested.

The use of ECAs for representing brainstorming partners or facilitator could enable us to further study the effects of social and affective interactions in a brainstorming task. In comparison to protocols involving acting experimenters, ECAs would have the advantage of being more easily controllable and of displaying repeatable behaviors. They could thus constitute a new experimental tool for exploring creativity processes.

3.2 Research Program

Evaluating creativity. In the following research program we intend to collect creativity metrics that are classically used in the literature [45], such as: the quantity of ideas generated (which is correlated to the quality of the production [52]), the width of production (i.e. the number of semantic categories represented), the depth of production (i.e. the number of semantically-related ideas), the semantic distance (i.e. originality) between the ideas and the initial problem. These metrics are generally submitted to inter-judge agreement procedures.

[2] See e.g. Guild Wars, www.guildwars.com

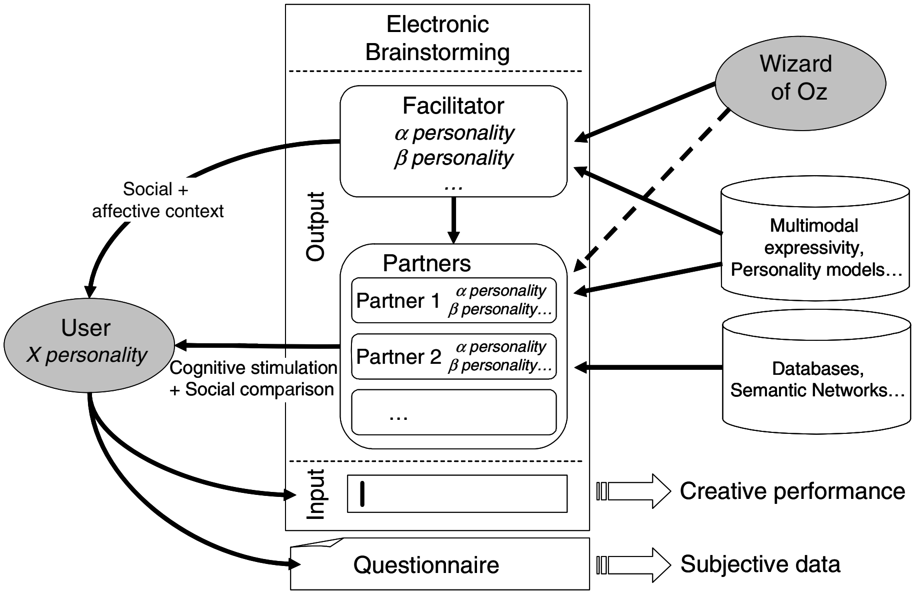

Fig. 2. General architecture of the experimental setups

Personification. The first step could be to introduce existing ECA models into a simple electronic brainstorming system. The goal would be to merely implement the personification hypothesis with ECAs' personality set to neutral (cf. Fig. 2 with expressivity and personality models deactivated). To justify the presence of ECAs and facilitate experimental control, we may test only distant electronic brainstorming situations: indeed, such a procedure would enable us for example to simulate the behavior of all group members and test only one user at a time (instead of groups of users).

By combining different features of our system we could create the following range of experimental conditions:

- Collective distant electronic brainstorming (with no personification),
- Collective distant electronic brainstorming with an ECA facilitator,
- Collective distant electronic brainstorming with ECA partners and facilitators (the test user would first have to choose an avatar),
- Individual electronic brainstorming (cf. Fig. 2 with partners removed) with a non-personified facilitator,
- Individual electronic brainstorming with an ECA facilitator.

These experimental conditions would enable us to evaluate the effects of personifying the facilitator both on individual and collective creativity, and the effects of personifying the partners on collective creativity. The effects of personification should also be evaluated on users' subjective impressions. Furthermore, the collection of gender and personality data from the test users could enable us to identify potential relations between individuals' personality and their reactions (both on performance and subjective dimensions) to the presence of ECAs.

Personality. The following step would consist in manipulating the social and affective environment of electronic brainstorming by giving ECAs a strong personality. The most influencing character in the brainstorming might be the facilitator: therefore we assume that the effects of personality would be more clear-cut when implemented in ECA facilitators (in comparison to ECA partners). That is why we chose to especially emphasize this hypothesis in the present section.

To help us model the expression of personalities in the facilitator's role, we should first conduct a few pilot tests with human brainstorming participants and human facilitators acting within different communication styles, personalities, emotions, etc. Those (costly) pilot studies are not expected to produce significant experimental results because they may not be repeated a sufficient number of times. Their aim would rather be to feed a computational model of multimodal expressive behavior for ECAs.

With a trained model (eventually validated with replay procedures [9]) the large-scale experiments could be conducted by creating the following conditions (see Fig. 2):

- Collective distant electronic brainstorming with an ECA facilitator, α personality,
- Collective distant electronic brainstorming with an ECA facilitator, β personality,
- Individual electronic brainstorming (cf. Fig. 2 with partners removed) with an ECA facilitator, α personality,
- Individual electronic brainstorming with an ECA facilitator, β personality.

It should be noticed that several control conditions would be provided by the first research step (collective and individual conditions with no personification and with a neutral ECA facilitator).

For the moment the α and β (and so on…) personality traits have not been determined because this requires a closer literature analysis. However, we intend to test at least a positive (i.e. socially desirable) personality trait and a negative one. We wish to examine their effects on both the idea generation performance and the subjective experience of users. Finally, theses data would be crossed with user's gender and personality in order to investigate interaction effects between user's and facilitator's individual characteristics.

Extension to Other Kinds of Creativity. An example of medium- to long-term perspective to such a research could be to extend the experimental focus to other kinds of creativity, for example educational creativity (early-learning activities) dedicated to children, in individual or in collective modes. According to the results obtained in the previous research steps, some of the experiments could be replicated in order to test the generalization of the effects to other populations and other kinds of creativity. For example we could imagine that the cognitive and social mechanisms of creativity and their relation to the affective context could be different between children and adults.

4 Expected Outcomes

We think that the exploratory developments envisioned in this paper could have significant contributions to both the fields of creativity research and ECA design.

4.1 Contribution to Creativity Research

The potential benefits to the study of creativity process can be formulated as follows:

– Further modeling of cognitive, affective and social mechanisms of creativity: especially, the results about the influence of the affective context on creativity could help us understand the nature of creativity (an archaic capacity related to a feeling of danger or a modern evolution related to social comfort).
– Comparison between individual and collective creativity processes: are those the same and only mechanism? Does the environment of a group change the individual's reaction and adaptation?
– Comparison between children's and adults' creativity processes: to obtain reliable data on this topic we will have to ensure that the tasks (related to industrial and educative creativity) will remain fairly comparable. The creative educative task for children will have to be designed as an adaptation of the task submitted to adult users.
– Perspectives for new creativity-supporting tools: if the results appear to be easily transferable to a commercial development (e.g. a positive effect of personification, or of simple expressivity parameters), we could imagine to promote the design of more efficient tools to improve creativity, and indirectly industrial innovation.

4.2 Contribution to ECA Research

Finally, the research directions presented in this paper could be beneficial to the ECA community by the following aspects:

– Providing a context for modeling the behavioral expression of affects, of personality traits and social interactions from the way human facilitators behave.
– Comparison of the way users perceive a human / an ECA: do they reliably decode and interpret multimodal behaviors and personality?
– Providing improvement directions for the design of ECAs (based on the previous observations).
– Exploration of a new application field, and potentially identification of new usefulness elements.

5 Conclusion

Inspired by Kim and Baylor's approach with pedagogical agents [35], our goal in this paper was to introduce a preliminary social-cognitive framework to serve as a theoretical basis for and a guide to the optimal design of Embodied Creative Agents. In this respect, creative agents could be developed both as cognitive tools and as social tools for supporting creative processes: creative agents as cognitive tools could be equipped with databases and semantic networks for associative thinking and take turns when the user does not generate ideas. Besides, creative agents as social tools would be present on the screen, exhibit their own performance (ECA partners), express their personality and react to the user's behavior (ECA facilitator) in order to provide a social context for the creative practice.

The first set of agents that would be designed to afford these social-cognitive dimensions could then enable us to conduct a series of experimental studies that would in turn expand the social-cognitive framework: research on creative processes will be expected to progress through such a spiral iterative approach.

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