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Dynamic tabletop interfaces for increasing creativity

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ABSTRACT

We designed a tabletop brainwriting interface to examine the effects of time pressure and social pressure on the creative performance. After positioning this study with regard to creativity research and human activity in dynamic environments, we present our interface and experiment. Thirty-two participants collaborated (by groups of four) on the tabletop brainwriting task under four conditions of time pressure and two conditions of social pressure. The results show that time pressure increased the quantity of ideas produced and, to some extent, increased the originality of ideas. However, it also deteriorated user experience. Besides, social pressure increased quantity of ideas as well as motivation, but decreased collaboration. We discuss the implications for creativity research and Human–Computer Interaction. Anyhow, our results suggest that the Press factor, operationalized by Time- or Social-pressure, should be considered as a powerful lever to enhance the effectiveness of creative problem solving methods.

1. Goal of the research

The Organisation for Economic Co-operation and Development (OECD) considers innovation as essential to economic growth and to competitiveness, particularly in western countries. Innovation can be defined as an invention, or a new product, that meets a commercial success (Perrin, 2001). To manage this combination of invention and adequacy to the market, the top five methods used in industrial companies include creativity techniques (invention) as well as market analysis, cost analysis and methods for comparing solutions (Geis, Bierhals, Schuster, Badke-Schaub, & Birkhofer, 2008). Hence the development of effective creativity techniques appears crucial for industrial innovation.

The general aim of our research is to improve such creativity techniques. For this purpose, we will present in this article three contributions. The first one is a conceptual contribution, focused on improving creativity through the Press factor. This is an original and challenging approach, which has been poorly investigated in the creativity literature. Hence we also refer to the domain of human performance in dynamic environments to better understand the effects of pressure. The second contribution is an operational one, taking the aforementioned conceptual elaboration as a basis for the design of a computer mediated tabletop interface for group creativity. This interface includes graphical artifacts implementing two kinds of pressures: time pressure and social pressure. This kind of contribution is also original in the creativity literature, which usually focuses on methods rather than on interactive tools to support groupwork. Finally, the third contribution is an experimental one, allowing us to quantify the effects of our implementation of pressure on three kinds of variables: in this respect we provide new knowledge about the potential impact of pressure on (1) performance to the creative task, (2) collaboration behavior, and (3) subjective experience of participants.

2. Overview on creativity

Creativity is the ability to produce work that is both novel and appropriate (Sternberg, 1998). As initially proposed by Rhodes (1961), creativity can be seen as a construct of four "Ps": Person, Process, Product, and Press. The Person component refers to the individual characteristics and personality traits correlating to creativity. Research on this component (see e.g. Bolin & Neuman, 2006; Feist, 1998) has shown that creativity can be influenced by certain personality traits such as psychoticism, social anxiety, openness, impulsivity, individualism, extroversion. The Process relates to the cognitive mechanisms of creativity. In this respect, the role of associative processes in divergent thinking and problem solving has been repeatedly emphasized (Nijstad & Stroebe, 2006; Runco, 2004), as well as the mechanisms related to group creativity, such as cognitive stimulation and social comparison (Dugosh & Paulus, 2005). The Product refers to the creativity outcomes and their evaluation criteria, with the assumption that studies of products like publications, paintings, poems, or designs are highly objective.

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Finally, Press corresponds to the contextual and environmental factors interacting with creativity. A broad overlook at the creativity literature suggests that this component was much less studied than the 3 other P-factors (see literature reviews from Runco, 2004; Zeng, Proctor, & Salvendy, 2010). According to Runco (2004), the concept of "Press" can be attributed to Murray (1938) and describes pressures on the creative process or on creative persons. Two types of pressures can be distinguished: alpha pressures which are the objective aspects of press, and beta pressures which correspond to people's subjective interpretations of contextual pressures. For example, competition, which is an objective contextual factor, may stimulate or inhibit creativity depending on individual's interpretation.

Amabile (1983) defends the general view that extrinsic constraints or pressures, by impairing intrinsic motivation, have a detrimental effect on creative performance. More specifically, Runco (2004) emphasizes that time pressure should be avoided when a creative outcome is expected: time is important for incubation, and for creative work. He cites the example of outstanding creative achievements like Darwin's theory of evolution which required sustained efforts and time to elaborate. Likewise, McFadzean (1998) reports that the development of post-it notes by 3M was possible only because the company allowed their inventor Arthur Fry to spend time working on the concept. However, Amabile herself (1983) observed inconsistent effects of extrinsic pressures on the outcomes of creative tasks. She hypothesized that extrinsic pressures have a negative impact on heuristic creative tasks (when it is not specified what should be done to produce a creative response) whereas they can have a positive impact on algorithmic creative tasks (when people know explicitly how to produce a creative response). The abovementioned examples of Darwin's theory of evolution or 3M's post-it notes, as well as employees' daily activity at work, all refer to heuristic tasks in which people are not told what to do to be creative. In contrast, we are interested in the present study to examine the effects of the Press factor on a brainstorming task, whose method attempts to render creativity more algorithmic.

Brainstorming in Osborn's seminal framework (1953) is a clearly-defined and structured task, with explicit rules, applied in a limited timeframe, within the scope of a designated paradigm. This active creative method was developed in order to help people overcome cognitive fixations. Indeed, the limited capacity of short-term memory and the automatic spreading activation mechanisms explain why people are often limited to a narrow, familiar, and bounded subset of the problem space. Cognitive fixations result in ignoring about 80% of potential solution space and being unaware of doing so (see review by Zeng et al. (2010)). Venturing beyond the highly familiar categories requires efforts and Osborn's brainstorming method was developed to support such process. It is a group method relying on two basic principles: deferment of judgment and quantity leads to quality. Deferment of judgment emphasizes the need for separating ideation and evaluation. Because original ideas may appear unusual or slightly bizarre, they might easily fall victim to self-censure and censure from others (Stroebe, Nijstad, & Rietzschel, 2010). Furthermore, emphasizing quantity of ideas as the desired outcome further reduces group members' tendency to be critical of the ideas produced. It was actually shown in experimental studies that quantity of ideas correlates to the number of high-quality ideas (e.g. $r = 0.69$ in Parnes and Meadow (1959); $r = 0.82$ in Diehl and Stroebe (1987)).

Brainstorming is also meant to be a playful activity, which is likely to increase its effectiveness to free the group's creative potential (VanGundy, 1997). According to McFadzean (1998), research at the University of Michigan showed that laughter causes the release of endorphins, which in turn provide a burst of energy and an impetus to creativity. It can also help group members take things less seriously thus reducing self-censorship. In this respect, the Press-factor could also be seen as a potential lever to playfulness since challenges, rewards, or time pressure are classical workings of game design.

To summarize, we have seen in this section that although pressures are considered detrimental to heuristic creative tasks, it cannot be excluded that they could improve other tasks such as brainstorming. Indeed, because brainstorming in Osborn's framework tends to make creativity more algorithmic, it could respond positively to pressure. To further reason on the potential impact of pressure on creativity, we examined the literature related to the effects of pressures on different kinds of cognitive and collaborative activities. This research field, focusing on human activity in so-called "dynamic environments", proved fruitful to structure our study of creativity, as we will show in the next section.

3. Human activity in dynamic environments

Osman (2010) opens her literature review of human activity in dynamic environment by providing six examples of activities that seem eclectic at first sight: ecosystem control, automated pilot management, incineration plant monitoring, investment game, sugar factory plant control, and water purification system. However, these tasks all involve complex sequential decision making and occur in what she calls "complex dynamic environments". These are uncertain environments, changing either as a consequence of human actions, autonomously, or both (Osman, 2010). For this reason, complex dynamic environments bear the risk for the human operator of losing control. Task complexity is related to the characteristics and the number of elements and relations it is necessary to account for (Hoc, Amalberti, & Plee, 2000). Osman's (2010) unifying approach of economics, engineering, ergonomics, Human–Computer Interaction, management, and psychology, results in identifying four main sources of uncertainty in complex dynamic environments (see also Funke, 2001): (1) time pressure, (2) feedbacks, outcomes and reactions of the system to the operators' actions (positive, negative feedback, unpredictable, unreliable, invalid or invisible one...), (3) involvement of multiple actors and stakeholders, and (4) ill-structured problems with shifting, ill-defined, or competing goals.

Research on time pressure has identified many ways in which cognitive processes change with time pressure. In this respect, a number of contradictory findings were reported (see Maule, Robert, Hockey, & Bdzola, 2000): time pressure has sometimes been shown to increase the quality of decision-making, and sometimes to reduce it, to induce less extreme judgments, to reduce the propensity to take risks, etc. For example, Kerstholt (1994) simulated a diagnosis task involving a virtual athlete running a race: subjects had to monitor the athlete's fitness level over time and react accordingly. Declines in fitness level could be caused either by dehydration, cardiac overload, overheating or a false alarm. The subjects had to diagnose the problem by consulting the athlete's physiological parameters and administer the adequate treatments (give water, rest or cool). In this study, the complex dynamic environment was characterized by: the autonomous evolution of the athlete's fitness level, time pressure (operationalized as speed of system decline), the diagnosis task which is ill-structured by nature, and the system feedback to the subject actions. The results show a general speedup of information processing as time pressure increases, up to a maximum where the strategy fails and leads to system collapse (inverted U-shaped relation between time pressure and performance).

Finance is another field in which decisions have often to be made under time pressure. Kocher and Sutter (2006) examined the influence of time pressure and time-dependent incentive