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Research Report

Electrophysiological evidence for emotional valence and competitive arousal effects on insight problem solving

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ABSTRACT

Accumulating evidence suggests that insight can be substantially influenced by task-irrelevant emotion stimuli and interpersonal competitive situation, and a close link might exist between them. Using a learning-testing paradigm and Event-Related Potentials (ERPs), the present study investigated the independent and joint effects of emotional and competitive information on insight problem solving especially their neural mechanisms. Subjects situated in either competitive or non-competitive condition learned heuristic logogriphs first and then viewed task-irrelevant positive or negative emotional pictures, which were followed by test logogriphs to solve. Both behavioral and ERP findings showed a more evident insight boost following negative emotional pictures in competitive context. Results demonstrated that negative emotion and competitive situation might promote insight by a defocused mode of attention (as indicated by N1 and P2), the enhanced semantic integration and breaking mental set (as indicated by N450), and the increased forming of novel associations activated by motivational arousal originating from competition (as indicated by P800–1600 and P1600–2500). These results indicate that the dynamic interactions between emotional valence and competitive arousal effects on insight.

"Feeling and longing are the motive forces behind all human endeavor and human creations."

—Albert Einstein, New York Times Magazine

1. Introduction

Insight is an important and particular phenomenon that has been identified as a form of creativity and linked to scientific and technical innovations (Dietrich and Kanso, 2010; Finke,

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1995; Friedman and Förster, 2005; Kounios and Beeman, 2009), and it is a topic of growing interest in psychological researches (Aziz-Zadeh et al., 2009; Bowden and Jung-Beeman, 2007; Jung-Beeman et al., 2005; Ludmer et al., 2011). Previous studies have revealed that an insight pops into the mind when one breaks free of the unwarranted assumptions (i.e., breaking mental sets) and forms efficient connections among the old concepts or cognitive skills (i.e., forming novel, task-related associations) (Bowden and Jung-Beeman, 2007; Luo and Knoblich, 2007; Mai et al., 2004; Qiu et al., 2008). Moreover, the relevant researches using ERPs have revealed different stages associated with these key and elementary processes of insight problem solving. Results showed that a negative component (N380 or N320) (Mai et al., 2004; Qiu et al., 2006a) may reflect the process of breaking a pre-established mental set or cognitive conflict. In addition, previous studies indicated that P1200–1500 (Wang et al., 2009), P900–1300 (Zhao et al., 2010) or P600–1100 (Xing et al., 2012) in the later stage might play an important role in the forming of novel associations during insight problem solving.

Just as important, understanding the mystery of insight requires exploring its important contributors which could give it impetus, such as emotional and motivational processes. This issue still remains ambiguous. Studies have indicated that emotion could act as a catalyst for creativity (e.g., Gasper, 2003; George and Zhou, 2002; Kaufmann and Vosburg, 2002). However, focusing more directly on neural mechanisms underlying this function presents an incomplete picture. To our knowledge, only two studies have empirically investigated the neural mechanisms of insight that are influenced by mood or emotion. Using fMRI, Subramaniam et al., (2009) examined the effects of moods on brain activity during preparation for insight problems via measuring individual baseline mood states. However, cognitive flexibility is not only modulated by the longstanding mood states, but also by simply viewing emotional stimuli for a short time (Sakaki and Niki, 2011). Even mild fluctuations in emotion can have the potential to produce significant effects on cognitive processing and neural activation (Mitchell and Phillips, 2007, Rudrauf et al., 2009; Yuan et al., 2011). Besides, because naturally existing mood states and unmeasured/unknown extraneous variables are generally in the relationship of co-variation, it is possible that a third variable might explain the effects of mood states on insight observed in this study. A recent neuroimaging research (Sakaki and Niki, 2011) examined how transient viewing of positive and negative images (660 ms) influenced subsequent understanding of solutions to insight problems. In this research, insightful riddle solving processes were catalyzed by presenting the correct answers. However, understanding the solution after being told it was not an insight in the strict sense but an apperception or an outsight (e.g., Sheth et al., 2009; Smith and Kounios, 1996). Receiving answers passively might lack the necessary and typical characteristics of insight (i.e., impasse experience or problem restructuring) (Luo and Knoblich, 2007). The cognitive and neural processes that support actively solving the problem and passively understanding the answer are actually different in insight (Luo and Knoblich, 2007; Qiu et al., 2010). Therefore, it is advisable to make comprehensive analysis of the effects of experimentally induced emotion on the cognitive processes of true insight.

Additionally, these studies lacked a consideration of situation-dependent influences (e.g., specific situations stimulating enhanced goal motivation and greater task involvement). Previous works revealed that there are certain conditions under which emotional processes may be more likely to be activated (e.g., Schultz et al., 2008). For example, emotion can impact information processing in a "state-dependent" manner on the basis of motivational processes (e.g., reward-related manipulations) (Pessoa, 2009). And some neural circuits might be specific to the hedonic valence and deploying different responses depending on the goal (Lang and Bradley, 2010). Therefore, based on these findings, it makes sense to assume that the effects of positive and negative emotion on insight are more complex and context-dependent.

Competition, as a situation-specific motivator and frequently used energizer, may have a particular relevance to creativity. It is suggested that creative work frequently involves interpersonal competition (Abra, 1993). Some of the most creative scientific discoveries have been ascribed to the rivalry between competing laboratories (De Dreu and Nijstad, 2008; White, 2001). The evidence from creative work and innovators demonstrates that competition could enhance the excitement and challenge (Conti et al., 2001), providing a crucial motivation and energy source for creating (Abra, 1993). Although previous researches have provided some information regarding competition and creativity, only little information is available about the impact of competitive stimuli on the specific cognitive processes involved in insight. Thus, we would like to know at which stage of insight problem solving (e.g., breaking mental sets and forming novel associations) competitive information exerts its impact on competitor's mind. Consequently, it is important to overcome some limitations of the traditional behavioral measures that dominate the relevant literature and examine the time course of insight problem solving during competition.

Also, most behavioral studies of competition–creativity link did not explore the potential role of emotion variation in it. Lazarus (2000) proposed that the important psychological functions that influence competitive performance could be influenced by emotion. In addition to this, previous studies have indicated that there is a reciprocal relationship between coping strategies and emotions of individuals during a stressful situation (Carver and Scheier, 1994; Cerin et al., 2000; Clark et al., 1995; Crook et al., 1998; Folkman and Lazarus, 1985; Lazarus and Folkman, 1984; Ntoumanis and Biddle, 1998). The emotion feelings might be the crucial moderators of stress-related (Cavanagh and Allen, 2008) or goal-oriented (Izard, 2009) performances of cognitive functioning. An integration of emotion and cognition in brain functional organization would allow the goal-directed behavior to depend on the emotional state (Gray et al., 2002). Moreover, the coping actions and emotional experience of individuals may change across situations and across different points in time during a stressful situation (e.g., competitive sport settings) (Lazarus and Folkman, 1984; Gaudreau et al., 2002). Based on these suggestions, it is likely that the influence of competition on the time course of insight may be mediated by the impact of emotion.