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Creative motivation: Creative achievement predicts cardiac autonomic markers of effort during divergent thinking

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ABSTRACT

Executive approaches to creativity emphasize that generating creative ideas can be hard and requires mental effort. Few studies, however, have examined effort-related physiological activity during creativity tasks. Using motivational intensity theory as a framework, we examined predictors of effort-related cardiac activity during a creative challenge. A sample of 111 adults completed a divergent thinking task. Sympathetic (PEP and RZ) and parasympathetic (RSA and RMSSD) outcomes were assessed using impedance cardiography. As predicted, people with high creative achievement (measured with the Creative Achievement Questionnaire) showed significantly greater increases in sympathetic activity from baseline to task, reflecting higher effort. People with more creative achievements generated ideas that were significantly more creative, and creative performance correlated marginally with PEP and RZ. The results support the view that creative thought can be a mental challenge.

People's conceptions of creativity fall along a dimension of *romanticism* to *rationalism* (Sawyer, 2012). Romanticism, by far the most common perspective among the Western public, assumes that creativity is mysterious, that creative ideas arrive seemingly out of nowhere, and that, as a result, creativity is largely a matter of waiting for automatic and effortless inspiration. But rationalism, the guiding perspective in the science of creativity (Finke, Ward, & Smith, 1992; Weisberg, 2006), assumes that creativity involves ordinary cognitive processes and that creativity can be guided, controlled, and trained.

Motivation is a major concept in the rationalist perspective (Sawyer, 2012). Because developing creative ideas is seen as something people can control, motivational processes like incentives (how much do people value doing something creative?), difficulty (how hard is the creative challenge?), and effort (how hard are people trying?) are important for understanding when and why people engage in creative processes rather than stick to the familiar methods. Most research on motivation and creativity, however, has concerned itself with incentives, such as how rewards can inhibit or stimulate creative thought (e.g., Hennessey, 2000, 2010).

In the present work, we examine the relatively unexplored area of effort during creative tasks, using cardiac autonomic markers of motivation. Not much is known about how hard people try during the creative process and whether the effort they exert relates to the creative quality of their work. Motivational intensity theory (Brehm & Self, 1989), a general model of effort (Gendolla, Wright, & Richter, 2012), offers a useful framework for understanding effort during creative activities. When a task allows people to work at their own pace and thus accomplish as little or as much as they would like, effort is a function of the importance of the goal at stake (Wright, 2008; Wright, Killebrew, & Pimpalapure, 2002). The present research used such a task—an unfixed, self-paced divergent thinking task (Silvia et al., 2008; Wallach & Kogan, 1965), in which people are given 4 min to come up with unusual uses for a common object. People are told that the creativity of the ideas is more important than the number of ideas, and they can come up with as many or as few ideas as they wish. For tasks like this, effort should be a function of the importance of doing well.

To explore the role of importance in creative effort, we turned to individual differences in creative achievements. People vary widely in creative achievements (Carson, Peterson, & Higgins, 2005; Feist & Barron, 2003; Grosul & Feist, 2014; Richards, Kinney, Benet, & Merzel, 1988), which are public and observable markers of creative behaviors, such as receiving awards, obtaining fellowships, being reviewed in major periodicals, and publishing, exhibiting, and performing creative work in important venues. Not surprisingly, people with many creative achievements often choose creative college majors and occupations (Silvia & Nusbaum, 2012), see themselves as creative people (Silvia, Wigert, Reiter-Palmon, & Kaufman, 2012), and score much higher in openness to

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experience, a broad personality trait associated with creative and aesthetic interests (Carson et al., 2005; Kaufman, 2013; Nusbaum & Silvia, 2011b; Silvia, Nusbaum, Berg, Martin, & O'Connor, 2009; Silvia, Beaty, et al., in press). People with more creative achievements, given their record of investing their time and energy into creative work, should value doing well on the creativity task relatively more, which should be reflected in physiological markers of effort.

Creative effort is intriguing for a few reasons. The specific question of effort-related autonomic activity during creative problems, for example, has received virtually no attention in creativity research or effort research. Creativity tasks are interesting contexts for mental effort because—unlike the simple memory or judgment tasks commonly used in effort research (e.g., Brinkmann & Franzen, 2013; Silvia, 2012)—they require people to apply abstract, higher-order processes to ill-structured problems (Finke et al., 1992; Weisberg, 2006). More generally, studying effort during creativity tasks can inform the broader ongoing debate over the role of controlled, executive processes in creativity. Early creativity theories emphasized automatic and low-level associationistic processes, such as spreading activation in semantic memory and structural differences in knowledge organization (e.g., Mednick, 1962; Wallach & Kogan, 1965). Recent research, however, has argued that deliberate, effortful processes are central to creativity (Benedek & Neubauer, 2013; Jauk, Benedek, & Neubauer, 2014; Nusbaum & Silvia, 2011a). For example, finding and using abstract strategies (Gilhooly, Fioratou, Anthony, & Wynn, 2007), searching for knowledge despite interference (Benedek, Könen, & Neubauer, 2012; Lee & Therriault, 2013; Silvia & Beaty, 2012; Silvia, Beaty, & Nusbaum, 2013), self-regulating to approach-oriented goals (e.g., Zabelina, Felps, & Blanton, 2013), and exerting executive control over thought (Beaty & Silvia, 2012, 2013; Benedek, Franz, Heene, & Neubauer, 2012; Benedek, Jauk, Sommer, Arendasy, & Neunauer, 2014) improve the creativity of people's ideas and typically require mental effort. All of the work to date, however, has used behavioral measures of creative performance, so physiological measures of the underlying effort processes would greatly illuminate whether doing well on creativity tasks is associated with higher effort.

Our physiological outcomes were measures of sympathetic and parasympathetic influences on the heart. Research on motivational intensity theory has emphasized sympathetic outcomes as markers of effort, such as systolic blood pressure (Wright, 1996; Wright & Kirby, 2001) and the cardiac pre-ejection period (PEP; Kelsey, 2012; Obrist, Light, James, & Strogatz, 1987). In our project, we used PEP—the time difference between the onset of contraction (the ECG Q point) and the opening of the aortic valve (the impedance cardiograph's [ICG] B-point)—as our primary sympathetic measure. PEP has been widely used in recent effort research (see Gendolla et al., 2012; Richter, 2013). Many studies have found evidence for its validity as a marker of effort in active coping contexts (for reviews, see Gendolla et al., 2012; Richter, 2012), such as studies that manipulate incentives and rewards (e.g., Brinkmann & Franzen, 2013; Richter & Gendolla, 2009). The RZ interval—the time difference between the ECG R-peak and the ICG *Z*-peak (Cybulski, 2011)—was included as an exploratory sympathetic outcome. Also known as the initial systolic time interval (ISTI; Meijer, Boesveldt, Elbertse, & Berendse, 2008), the RZ interval uses points that are more easily identified (the ECG and ICG peaks) and appears to work as well as or better than PEP in many studies (van der Meer, Noordegraaf, Bax, Kamp, & de Vries, 1999; van Lien, Schutte, Meijer, & de Geus, 2013; Wilde et al., 1981), so it is worth exploring.

To assess parasympathetic influence, we measured heart rate variability (HRV; Grossman & Taylor, 2007). Although motivational intensity theory is primarily concerned with sympathetic processes, several studies have explored possible parasympathetic effects (Richter, 2010; Silvia, Eddington, Beaty, Nusbaum, & Kwapil, 2013). Some research points to HRV as a marker of self-regulation and effort in its own right (Segerstrom, Hardy, Evans, & Winters, 2012; Segerstrom & Nes, 2007), and HRV is prominent in studies of stress, frustration, and emotional control (Graziano & Derefinko, 2013). Research on HRV uses several metrics (Allen, Chambers, & Towers, 2007; Grossman & Taylor, 2007). We quantified HRV with respiratory sinus arrhythmia (RSA), a frequency-domain measure that uses spectral methods to estimate HRV within the respiratory frequency band, and the root mean square of successive differences (RMSSD).

In summary, participants in the present research worked on a divergent thinking task, a classic creative challenge (e.g., Christensen, Guilford, & Wilson, 1957), while being monitored for changes in sympathetic and parasympathetic activity. We expected that people who valued creativity—people with many creative achievements, reflecting their investment in creative pursuits—would show greater effort during the divergent thinking task, as reflected by an increase in sympathetic activity from baseline to task.

1. Method

1.1. Participants

The data are from a larger study on individual differences and cardiac autonomic markers of effort (see Silvia, Nusbaum, Eddington, Beaty, & Kwapil, in press). Neither the creativity task nor the measures of creative achievement have been analyzed or reported in past work. A total of 111 adults—70 women (63%), 41 men (37%)—volunteered to participate and received either $10 USD in cash or credit toward a research option in a psychology class. All but 3 participants were students in the university; most of the people who participated for cash were undergraduate or graduate students from a wide range of majors who were not enrolled in psychology courses. The mean age was 19.3 years ($SD = 1.7$, range from 18 to 28 years), and the sample was diverse: 65% European American, 32% African American, 7% Hispanic or Latino, and 4% Asian or Pacific Islander (people could pick several categories or decline to pick any). The sample, on average, was on the border of overweight and normal weight, according to body mass index (BMI) scores based on self-reported height and weight ($M = 24.34$, $SD = 4.64$). The final sample of 111 was part of a larger sample from which 21 people had been excluded. Sixteen non-native speakers of English were excluded because the main task involved verbal creativity, and 5 people were excluded because of hardware or software problems during the session or cardiovascular disorders.

1.2. Measures

1.2.1. Creative achievement

To measure past creative achievements, we included the Creative Achievement Questionnaire (CAQ; Carson et al., 2005). The CAQ is a widely used measure of major creative accomplishments that has strong psychometric properties (for a review, see Silvia et al., 2012). The CAQ has 10 subscales that assess creative achievements in different domains, such as music, visual art, and writing. Receiving high scores requires having creative achievements that are public, observable, and recognized by people important in the domain. CAQ scores are thus highly skewed. For example, most college students receive a total score of 0 or 1 when all 10 subscales are summed (Silvia, Kaufman, & Pretz, 2009), so getting beyond a 1 takes notable public accomplishments. As in past research, we averaged the 10 domain scores and then log-transformed the overall score to adjust for the significant skew (see Silvia et al., 2012).

1.2.2. Divergent thinking

For the creative challenge, we used a divergent thinking task. Divergent thinking tasks are among the oldest and best established tasks in creativity research (see Kaufman, Plucker, & Baer, 2008). They appraise creative thought by asking people to move beyond obvious, common ideas and to generate unusual and interesting ideas. The most common variant is probably the unusual uses task, in which people are asked to come up with unusual uses for a common object. In our task, we asked people to come up with unusual uses for a brick. As in our extensive past work with these tasks (Silvia et al., 2008; Silvia, Kaufman, et al., 2009; Silvia, Martin, & Nusbaum, 2009; Silvia, Nusbaum, et al., 2009; Silvia, Beaty, et al., 2013; Silvia & Kimbrel, 2010), we instructed the participants to "be creative" and to "come up with something clever, humorous, original, compelling, or interesting." People could come up with as many responses as they wished, but we emphasized that creative quality was more important than quantity. The task lasted for 4 min.

Responses to the brick task were scored for quantity and quality. Quantity—usually known as *fluency*—was simply the total number of responses people generated. Creative quality was measured using subjective scoring