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Can Video Games Enhance Creativity? Effects of Emotion Generated by *Dance Dance Revolution*

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What role does emotion play in helping youth reach their creative potential? Does it alter how they process ideas, and how many ideas they can generate? By varying the levels of arousal associated with low, medium, and high levels of exertion in the video game *Dance Dance Revolution*, and inducing a positive or negative mood, this study offers evidence that emotion significantly affects creativity through the interaction of arousal and valence. Faced with the cognitive demand of creativity, lower arousal levels resulted in higher creativity scores when coupled with a negative mood. At high arousal levels, a positive mood resulted in greater creative potential than a negative mood. These results are discussed here in light of theories of emotion as a prime, as information, and as a moderator of attention.

Increasingly, games are being used in a variety of educational settings, from traditional classrooms (Moreno-Ger, Burgos, Martinez-Ortiz, Sierra, & Fernandez-Manjon, 2008) to corporate training (Kim, Bonk, & Zeng, 2005) to military exercises (Losh, 2006). The appeal of games is obvious. They immediately engage learners and bring a fun element to learning—what Shneiderman (2004, p. 1) called "fun in doing"—leading to creative problem-solving. They can also lead to more negative emotions, such as frustration, while pursuing a goal. In addition, playing video games can be an intense experience. If realizing creative potential is the goal, how might emotion, positive or negative, with more or less intensity, affect creativity?

This question was investigated with an experiment where participants played the video game *Dance Dance Revolution* that generated arousal based on three levels of physical exertion, followed immediately by mood induction. They were then administered a creativity test with both figural and verbal elements.

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ASSUMPTIONS AND DEFINITIONS

The hypotheses of this study were guided by theories on emotion, media effects, and creativity. Our study chose a classic, two-dimensional model of emotion comprising the conceptually orthogonal elements of valence and arousal. Valence is the extent to which an individual feels positive or negative, and arousal is the extent to which he or she feels energized either physically or mentally. The media-effects theory of excitation transfer was tested to see if energy, either physical or mental, would be transferred from one realm to another (Zillmann, 1971, 2002). The definition of creativity in this study is rooted in associative theory (Mednick, 1962), which posits that creativity is the formation of associative elements into new patterns that either meet specified requirements or are useful. Toplyn (1999) and others have suggested that creative people defocus their attention to retrieve a wide array of ideas, leading to original solutions. Martindale (1999) has hypothesized that creative people are able to vary the focus of their attention as needed for the task at hand. This study operationalized creativity as ideation, measured as the amount of novel ideas generated, rather than on the whole creative process, which can include problem solving, generating ideas and evaluating them (Runco & Chand, 1995).

The Effect of Arousal on Creativity

It can be argued that a significant factor in emotion is the intensity of arousal (Toplyn, 1999). At least three classes of theories support the notion that arousal will affect cognitive processes in ways that meaningfully impact creativity.

Arousal as activation theories. Some research has defined arousal as the activation of one's processing capacity (Kahneman, 1973) and posited that as arousal increases, energy is released into various physiological systems in preparation for activity (Duffy, 1957; Hull, 1943; Malmo, 1959). Given the high cognitive demands of creativity, especially when it involves orchestrating pictures, sounds, and text for creating content, it is reasonable to expect that higher arousal would predict a better creative performance. But, an intriguing study conducted 100 years ago found that increasing the intensity of shock to mice increased their ability to discriminate brightness, but only up to a point (Yerkes & Dodson, 1908). Yerkes-Dodson law, defined as an inverted U shape relationship between arousal and performance, has been replicated across a wide range of domains for humans (Broadhurst, 1957, 1959; Duffy, 1957; Malmo, 1959; Schlosberg, 1954; Stennett, 1957).

However, performance in these studies has hinged upon cognitive focus on a few central cues that are relevant to the task at hand. Creativity is conceptualized by associative theorists as being quite the opposite—it depends on *defocused attention*, utilizing a wider range of cues, even cues that are not central to the task. As Toplyn (1999) pointed out, arousal is inversely related to attention deployment toward these peripheral cues: "As arousal increases, the range of cue utilization decreases, so only central and highly relevant cues are in focus.... As arousal decreases, cues which are incidental, remote, and on the periphery of attention would become available" (p. 142). Therefore, lower arousal makes available peripheral cues that are incidental and remote, allowing for a richer pool of associations from which one can construct an original response. Using EEG alpha wave activity as a measure of cortical arousal, Martindale and his colleagues (Martindale & Hines, 1975; Martindale, Hines, Mitchell, & Covello, 1984) have associated creativity with low activation. Based on this rationale, the first hypothesis proposed a negative relationship between arousal and creativity.

H1a: The lower the arousal, the higher the creativity.

Arousal and attention theories. An alternative formulation is Kahneman's (1973) proposition that an increase in arousal from stimuli that attract one's attention serves to restrict the cues used for guiding action in a sustained manner (Easterbrook, 1959, as cited in Kahneman, 1973). It would be reasonable, therefore, to expect a degradation of creativity at high levels of arousal because the universe of cues from which one selects to construct a creative response would be restricted. Using theories by Berlyne (1967) and Easterbrook (1959) and evidence from numerous studies, Kahneman (1973) summarized the relationship between arousal and attention as follows: For high levels of arousal, attention will narrow, and be more liable to change; it will be difficult to control attention by fine discriminations; and there will be systematic changes in strategy in various tasks. All of these factors are likely to disrupt a complex performance, like creativity, which relies upon sustained attention. Low levels of arousal may cause a failure to "adopt a task set" and "a failure to evaluate one's performance, resulting in an insufficient adjustment of the investment in capacity to the demands of the task" (Kahneman 1973, p. 42). This logic leads to the following prediction, which served as an alternative to H1a.

H1b: Moderate levels of game-induced arousal will facilitate creativity more than high and low levels of arousal.

Unidimensional theories of arousal. Underlying both H1a and H1b is the assumption that arousal serves as an energizer of physical performance. If arousal is, indeed, a generalized drive in the sympathetic nervous system that can energize behavior (Hebb, 1955; Zillmann, 1971, 2002), including expressive behavior (Cappella & Greene, 1982; Stern, 1974), then increased arousal should result in increased levels of self-reported energy during the task following the arousal (Zillmann, 1971, 2002). But after rising, self-reported energy should drop, in keeping with the Yerkes-Dodson law (Yerkes & Dodson, 1908), given its prevalence in numerous domains of human performance (Broadhurst, 1957, 1959; Duffy, 1957; Kahneman, 1973; Malmo, 1959; Schlosberg, 1954; Stennett, 1957). Therefore,

H2: As the level of game-induced physiological arousal increases, self-reported energy levels during a subsequent creative task will increase, up to a point.

The Effect of Valence on Creativity

At least three theories—affect as prime, affect as information, and cognitive tuning—would predict that happy moods generate more creative thinking than sad moods.

Affect as prime theories. Affect, or the valence dimension of emotion, is thought to prime related thoughts, and because the average person has more positive thoughts than negative thoughts, a positive affect will prime more thoughts than negative affect. This theory is partly based on a series of studies (Isen, Daubman, & Nowicki, 1987), which found that individuals in whom positive affect had been induced outperformed those in control conditions. They tended to categorize stimuli more inclusively, gave more unusual first associates to neutral words and found more solutions to problem-solving tasks. Therefore, our third hypothesis proposed,

H3: Positive valence will result in greater ideation than negative valence.

Affect as information theory. According to this theory, when faced with an ambiguous task such as creativity, people will assess the environment for clues on how to proceed (Schwarz & Clore, 1983). Based on observations that suggested that those in sad moods generated just as many new ideas as those in happy moods when restraint was removed, Gasper (2004) concluded that positive affect acted not as a prime, but as permission, to generate new ideas and to proceed without caution. Therefore, our study hypothesized,

H3a: The number of original ideas produced will be significantly higher in a positive mood than a negative mood.

Cognitive tuning theory. This hypothesis would be consistent with cognitive tuning theory, which suggests that the function of emotion is to inform individuals about the task environment. Kaufmann (2003) predicted that one aspect of ideation—fluency, or the number of relevant ideas—will improve with a positive mood because a large number of studies have associated positive affect with the production of more ideas, yet a few others have had mixed results or linked other aspects of creativity (problem definition or choice of strategy, for example) with negative affect. If a heightened positive mood increases a tendency toward loose processing and overinclusion, as some studies have suggested, then a positive mood would result in more, not necessarily better, ideas. Therefore, it was predicted that

H3b: A positive mood will facilitate greater fluency than a negative mood.

METHOD

To examine the direct and combined effects of arousal and valence on creativity, a 2 (valence) $\times$ 3 (arousal) between-subjects, fully-crossed factorial experiment was conducted. The first independent variable was valence with two conditions, either a positive or negative mood, and the second independent variable was arousal, with three levels of physical exertion–low, medium, and high. Valence was manipulated with a mood-induction procedure by providing participants a score on a purposely ambiguous emotion recognition test, while the level of arousal was based on playing the video game *Dance Dance Revolution* at three levels of physical exertion: low, medium, and high.[1] The dependent variable of creativity was assessed with the Abbreviated Torrance Test for Adults (Goff & Torrance, 2002).

Participants

A total of 90 individuals took part in the study, with 15 participants in each of the six conditions. The male/female ratio in the sample was 2:3. Of these, approximately 5% were Hispanic, 10% were African American, 15% were Asian, and 60% were Caucasian, with an average age of 22. Eighty-nine were undergraduate (82%) and graduate (18%) students enrolled at a large university in the mid-Atlantic region of the United States, and one was a prospective student. Seventy-three participants received class credit; 17 participated without any credit to observe how a quantitative research study is conducted. All students who received extra credit had an opportunity to receive the same amount of credit by completing an alternative assignment.

The study administrator recruited students face-to-face from communication and education classes and explained that the purpose of the study was to explore the relationship between emotion and cognition, through the video game *Dance Dance Revolution.* Students interested in participating signed up during class for a date and time to come to a laboratory on campus. All participants signed an informed consent form prior to their participation in the experiment.

Independent Variables

Given that the study's hypotheses predicted main effects for arousal and valence, it was important to keep them

[1]A mixed-design factorial experiment with a small sample was used to pretest whether varying exertion (Isen, Daubman, & Nowicki, 1987) or tempo of music (Husain, Thompson, & Schellenberg, 2002) would more reliably elicit arousal. We found that varying exertion induced significant differences in galvanic skin response, whereas the differences evoked by varying songs on beats per minute were not as clear-cut.

orthogonal. Although this study was motivated by the copresence of both dimensions in game-play, manipulating both within the game would serve to conflate the two. Arousal accruing from exertion by participants would have been confounded with valence because participants' real-time realization of their competitive status (winning or losing) might have dictated the degree to which they exerted during the game. Therefore, the study chose to manipulate the two via operationally distinct tasks rather than combine them in one game administration, although that is how they typically manifest in real game-play. Our interest here was theoretical, making it important for us to isolate the 2 IVs for their distinct contribution to the DV.

Valence. A 20-item emotion recognition booklet was compiled using photos from Paul Ekman and Wallace Friesen's book *Unmasking the Face* (1975). Next to each picture of a face were the words *anger*, *fear*, *sadness*, *disgust*, *happiness*, and *surprise*. Each participant was asked to identify the emotion in each face by circling one of the words. Written directions on the test indicated that success on the test would indicate important interaction skills, but failure would signal a deficiency or absence of interaction skills. Half the participants were told that they succeeded in the test (to induce positive valence) and the other half were told that they failed the test (thereby inducing negative valence). This procedure was based on established mood induction practices (e.g., Biswas, Riffe, & Zillmann, 1994).

Arousal. Each participant danced to the song *Pump Up the Volume* performed by M/A/R/R/S for *Dance Dance Revolution Extreme 2* for Sony Playstation 2, a video game product created by Konami Corporation. Beginner, light, and standard levels in the game corresponded to low, moderate, and high levels of activity (or arousal). The number of arrows a participant had to step on to succeed in the game increased with each level. The default setting of the game, designed for the average player, was light.

The galvanic skin response of each participant was recorded before, during, and after the stimulus by attaching the first and second fingers of his or her nondominant hand to a freshly cleaned transducer, squirted with a small amount of gel. The data captured the frequency of skin conductance responses (defined as the number of peaks with amplitudes that were $\geq .05$ micromohs during the stimulus), a measure that other experiments with the same criterion have linked to levels of arousal (e.g., Kelsey, Ornduff, McCann, & Reiff, 2001; Sigmon, Fink, Rohan, & Hotovy, 1996; Sokhadze, 2007).

Measures

Dependent variable. The Abbreviated Torrance Test for Adults (ATTA; Goff & Torrance, 2002), a paper-and-pencil test with both verbal and figural sections, was administered to participants to measure creativity. The overall score, a creativity index, was made up of four norm-referenced abilities and 15 criterion-referenced creativity indicators (Goff & Torrance, 2002).

The four abilities were fluency, originality, elaboration, and flexibility. According to the ATTA manual (Goff & Torrance, 2002), fluency is the ability to produce quantities of ideas relevant to the task instruction. Originality is the ability to produce uncommon ideas or ideas that are totally new or unique. Elaboration is the ability to embellish ideas with details, and flexibility is the ability to process information or objects in different ways.

The 15 criterion-referenced creativity indicators were identified in the two categories of verbal and figural responses. Verbal responses were rated in terms of richness and colorfulness of imagery, emotions/feelings, future orientation, humor (conceptual incongruity), and provocative questions. Figural responses were rated in terms of openness (resistance to premature closure), unusual visualization or different perspective, movement and/or sound, richness and/or colorfulness of imagery, abstractness of titles, context (environment for object, articulateness in telling story), combination/synthesis of two or more figures, internal visual perspective, expressions of feelings and emotions, and fantasy.

Other variables. In addition to the creativity exercise, participants were asked to rank how energetic they felt mentally and physically while taking the creativity test. Based on the Positive and Negative Affect Schedule Scale created by Watson, Clark, and Tellegen (1988), mental energy was measured by asking participants to rank how mentally energetic they felt during the creativity test, with questions such as: "When I started taking the test, I felt alert, attentive, interested, or determined." Participants were asked to mark their level of energy on a scale of 1 to 10, with 1 representing the lowest level and 10 representing the highest. Likewise, the participants ranked their physical energy during the creativity test on a 1 to 10 scale, with questions such as: "When I started taking the test, I felt active, excited, jittery or nervous."

Procedure

Each participant ($N = 90$) filled out demographic information on a prestimulus paper-and-pencil questionnaire. Next, each person completed the Emotion Recognition Test, described earlier, that asked him or her to identify the emotion in a face by circling one word from several. Written directions on the test indicated that success on the test would indicate important interaction skills; failure would signal a deficiency or absence of interaction skills.

After each person was finished, the study administrator took the clipboard with these pieces of paper, and invited the participant to play *Dance Dance Revolution*. Each participant was randomly assigned to one of the three levels of exertion, representing the three levels of arousal.

Each participant was then asked to take off his or her shoes and to stand behind the play mat while the study administrator set up the experiment. The administrator attached the first and second fingers of the participant's nondominant hand to a transducer wired to a galvanic skin response system. The administrator then explained how the game worked.

After 30 sec of gathering a baseline measure, the administrator directed the participant to step into the middle of the mat, and start the game. Throughout the game, participant's galvanic skin response was recorded. While the participant was dancing, the administrator ostensibly graded his or her Emotion Recognition test and awarded either a very good grade or a very bad grade to intentionally induce either a positive or negative mood, determined by tossing a coin.

Immediately after the song ended, the administrator asked the participant to stand quietly for another 30 sec while skin conductance was still being recorded. The administrator then detached the transducer from the participant's fingers, showed them their score on the Emotion Recognition Test, and then asked them to circle a number on a self-assessment manikin (SAM) scaled from 1 to 10 where 1 = *sad* and 10 = *happy*. The SAM scale (Lang, 1980) was the first of two manipulation checks for mood.

As soon as each participant completed the SAM scale, the study administrator began to read the instructions for the creativity test. Before each of the three sections of the test, one involving words, and two involving pictures, the administrator read written instructions to the participant as he or she read along with the administrator. The administrator allowed 3 min per section.

When the creativity test was finished, each participant completed an online questionnaire that asked participants to report their level of physical and mental energy (or attentional intensity) while taking the creativity test. Embedded at the end of the questionnaire was the second manipulation check that asked how much the participant agreed with the following statement on a scale of 1 to 10: "The person who corrected the Emotion Recognition Test was accurate about my ability to recognize emotions and my interaction skills."

Finally, the administrator debriefed the participant, offering the name of counseling services (in light of the mood manipulation), and thanked the participant.

Scoring

In scoring the creativity tests, the instructions provided by ATTA were strictly followed.

Activity One involved verbal responses and was scored with norm-referenced measures and criterion-referenced creativity indicators, discussed earlier in this article. Activities Two and Three involved figural responses and were scored the same way.

Following instructions in the scoring guide, the administrator summed the raw scores in the categories of fluency, originality, elaboration, and flexibility, and then assigned a scaled score based on a chart provided in the worksheet. The sum of the scaled scores was added to the raw score of the creativity indicators to obtain the creativity index score. Creativity index scores ranged from 1 to 7, with higher scores indicating greater creative potential.

RESULTS

A 2×2 factorial ANOVA indicated that the mood manipulation functioned as intended because there was a significant main effect for valence on the SAM score, such that those who received a good grade on their emotion recognition test rated their mood on a SAM scale as significantly more happy ($M = 7.84$, $SD = .28$) than those who received a bad grade ($M = 5.89$, $SD = .28$), $F(1,83) = 24.57$, $p < .001$, $\eta^2 = .21$. Another 2×2 ANOVA also indicated a significant main effect for valence on the manipulation-check question eliciting participants' perceived accuracy of their score on the emotion-recognition tests, $F(1,84) = 82.51$, $p < .0001$, $\eta^2 = .48$. Those who received a good grade on their emotion recognition test rated the administrator as significantly more accurate in assessing their test ($M = 7.58$, $SD = .33$) than those who received a bad grade ($M = 3.27$, $SD = .33$).

For the arousal manipulation check, a 2×2 factorial ANOVA revealed significant differences in the frequency of skin conductance responses or SCRs (i.e., number of responses with amplitudes ≥ 0.05 micromhos) corresponding to the assignment of low, medium and high levels of exertion, $F(2,67) = 14.17$, $p < .0001$, $\eta^2 = .33$. A post-hoc Student's *t*-test revealed that participants in the low exertion condition had significantly fewer SCRs ($M = 87.12$, $SD = 11.91$) than participants in the medium exertion condition ($M = 137.21$, $SD = 11.91$); participants in the medium exertion condition had significantly fewer SCRs than those in the high exertion condition ($M = 174.16$, $SD = 11.64$).

H1a predicted that lower arousal levels would be associated with higher creativity scores, and H1b predicted medium arousal would result in highest creativity,

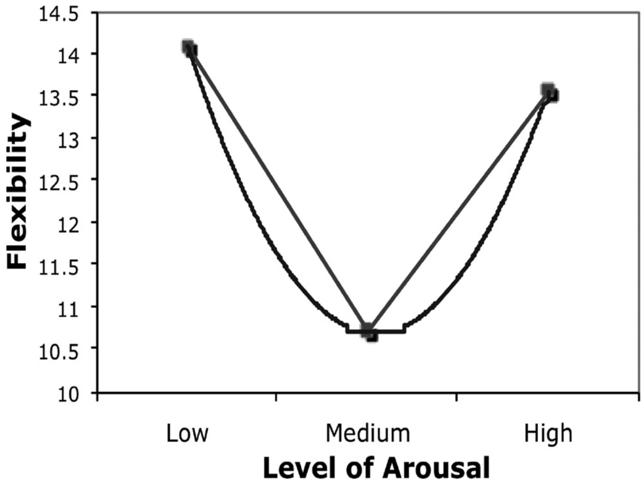

FIGURE 1 Flexibility as a function of level of arousal.

compared to low and high arousal. A 2×2 factorial ANOVA revealed that a main effect for level of arousal on flexibility approached significance, such that those who were at low ($M = 14.10$, $SD = 1.10$) and high levels of arousal ($M = 13.57$, $SD = 1.10$) received higher scores on flexibility than those at medium levels ($M = 10.73$, $SD = 1.10$), $F(2,84) = 2.71$, $p = .07$, $\eta^2 = .04$; see Figure 1. A significant quadratic trend $\beta = 3.1$, $p < .05$ lends partial support to H1a, but not to H1b. It appears that a low or high level of arousal, rather than a medium level, improved the ability to process information or objects in different ways, in this sample.

H2 predicted that an increased level of arousal induced by exercise would result in increased self-reported energy during the creative activity, but only up to an optimal level. The 2×2 factorial ANOVA revealed a main effect for level of arousal on self-reported mental energy, $F(2,81) = 3.38$, $p < 0.05$, $\eta^2 = .05$, with participants at a medium level of arousal reporting a significantly higher mean score for mental energy ($M = 30.57$, $SD = 1.09$) than those who participated at a high level ($M = 26.77$, $SD = 1.09$; see Figure 2).

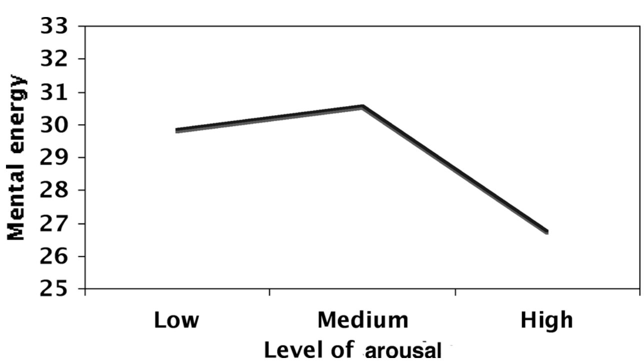

FIGURE 2 Mental energy as a function of level of arousal.

H3 predicted that valence would have a significant effect on the generation of ideas, with positive affect being stronger than negative affect. Positive valence would increase both the number of original ideas produced (H3a) and the number of relevant ideas produced (H3b). There was no main effect for valence on the creativity index, $F(1,84) = .14$, $p > .05$. A 2×2 factorial ANOVA revealed a near-significant main effect for valence on the number of new ideas (originality), $F(1,84) = 3.20$, $p = .08$, $\eta^2 = .02$ but in a direction counter to H3a. Negative valence produced more original ideas than positive valence. There was no main effect for valence on the number of ideas produced, $F(1,84) = .55$, $p > .05$. Therefore, H3 did not receive support from our data.

Exploratory Findings

Aside from the main effects pertaining to the proposed hypotheses, the 2×2 factorial ANOVAs revealed two significant interactions between valence and arousal: one on the overall creativity index, $F(2,84) = 3.43$, $p < .05$, $\eta^2 = .05$ (see Figure 3) and one on fluency or number of ideas, $F(2,84) = 6.65$, $p < .01$, $\eta^2 = .11$ (see Figure 4). Both were transverse (or crossover) interactions, which explains why the hypothesized main effects were not significant for these dependent variables.

Although H1a was supported in that lower arousal levels were associated with higher creativity scores, the interaction extends that finding and shows a more complex picture of the effects of emotion on creative potential in this sample: Low arousal levels resulted in higher creativity scores only when coupled with a negative mood. At high arousal levels, a positive mood resulted in higher creative scores.

Although H3 predicted that positive valence would have a significant effect on the generation of ideas, the

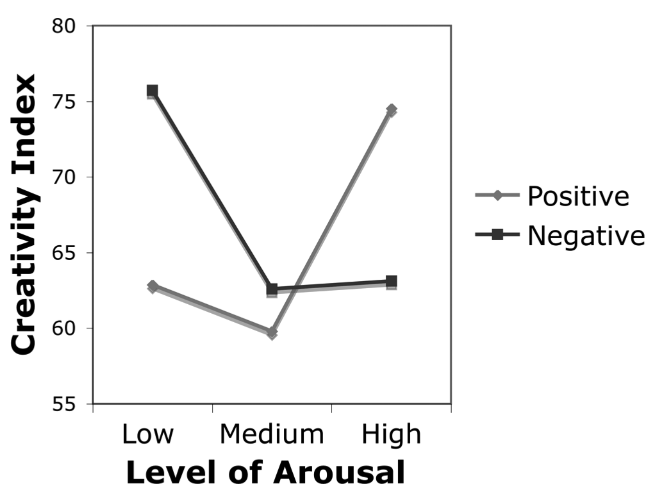

FIGURE 3 Overall creativity as a function of the interaction between valence and arousal.

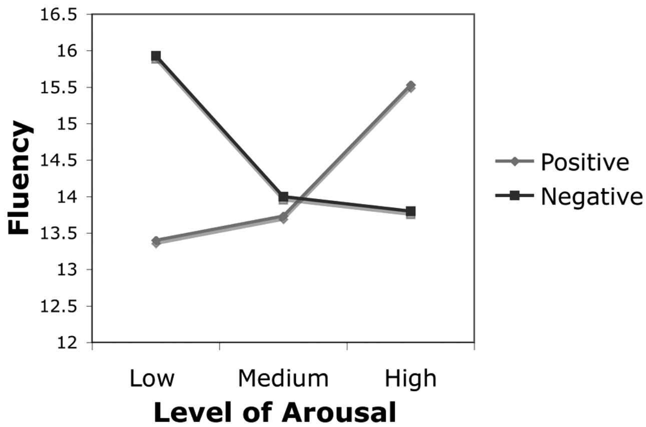

FIGURE 4 Fluency as a function of the interaction between valence and arousal.

interaction clarified support for that prediction by showing that the effect of positive valence was true only under conditions of high arousal in this sample. The interaction also showed that the combination of negative valence and a low level of arousal yielded the highest creativity index score. The means associated with this interaction in Table 1 showed that the combination of either negative valence-low arousal level or positive valence-high arousal level was more potent in stimulating creativity than any other combination of arousal and valence.

Although H3b predicted that a positive mood would facilitate fluency, the interaction of valence and arousal revealed a more complex picture that is similar to its effect on the overall creativity index, only stronger. In this sample, fluency was not affected by positive valence alone, but was at its highest when positive valence was combined with a high level of arousal; still, this condition was second to the highest score for fluency found in the low arousal–negative valence condition. Table 2 and Figure 4 illustrate the pattern of means found in this interaction.

TABLE 1
Creativity Index Scores: Valence × Level of Arousal

	Levels of Arousal		
Valence	*Low*	*Medium*	*High*
Negative			
M	75.73_{A}	62.60_{BC}	63.13_{ABC}
SE	4.65	4.65	4.65
Positive			
M	62.87_{ABC}	59.80_{C}	74.53_{AB}
SE	4.65	4.65	4.65

Note. Horizontal means with no subscripts in common differ at $p < .05$ according to Tukey-Kramer HSD post-hoc test.

TABLE 2
Fluency Scores: Valence × Level of Arousal

	Levels of Arousal		
Valence	*Low*	*Medium*	*High*
Negative			
M	15.93_{A}	14.00_{BC}	13.80_{C}
SE	.58	.58	.58
Positive			
M	13.40_{C}	13.73_{C}	15.53_{AB}
SE	.58	.58	.58

Note. Horizontal means with no subscripts in common differ at $p < .05$ according to Tukey-Kramer HSD post-hoc test.

DISCUSSION

The two main effects of the arousal dimension of emotion on creative potential and the significant interaction between valence and arousal on the overall creativity index and fluency hold important implications for theory and practice.

The main effect of arousal on flexibility, i.e., the ability to process information or objects in different ways (Goff & Torrance, 2002), indicates that a moderate level of arousal did not foster flexibility in this sample, whereas high and low levels did. It appears that both low and high levels of exertion led to broader and defocused attention, resulting in an increased pool of resources from which to draw creative thoughts, thereby highlighting the importance of arousal in associational theories of creativity.

The study also found that the level of mental energy (how alert, attentive, interested or determined a participant felt) was correlated with the level of arousal, up to a threshold point. It appears that physiological activation was transferred from the stimulus of *Dance Dance Revolution* to a subsequent creative task or expressive behavior, in support of theoretical formulations such as excitation transfer theory (Zillmann, 1971). Game-induced arousal may have increased participants' capacity for cognitive tasks, as claimed by activation theorists (Duffy, 1957; Hull, 1943; Malmo, 1959).

However, an important discovery of this study is that the degradation of cognitive performance at very high levels of arousal, noted by the Yerkes-Dodson law (Yerkes & Dodson, 1908) and demonstrated here by the self-reported drop in mental energy, can indeed be beneficial for fostering creativity. Assuming that arousal at high levels degrades performance by distracting focus on central and relevant cues, it is cognitively similar to a low-arousal state in that it makes available peripheral cues that are incidental and remote, thereby enriching the pool of associations needed for expressing creativity.

Because creativity was highest under low arousal–negative valence conditions and high arousal–positive conditions in this study, it may be inferred that the type of attention associated with creativity—defocused attention (Toplyn, 1999)—was highest in those conditions. Toplyn used EEG measures to find direct evidence that high scorers on another divergent thinking test, the Alternate Uses Test, spent more time during that test, exhibiting slow alpha rhythms, a state that has been associated with relaxation, diffuse attention, and lower arousal levels. Results reported here support his findings in that the highest scores on creativity and fluency were produced by those in the low arousal-negative mood condition. In addition to the combination of negative valence and low arousal, our finding of high creativity under conditions of positive valence and high arousal suggests another recipe for inducing creativity, but it is unclear how this combination would lead to defocused attention.

Aside from defocusing one's attention, emotion could also serve as an assessment tool. Creativity as a process may be divided into stages, as suggested by cognitive tuning theory (Kaufmann, 2003). If the creative process follows a linear path, then perhaps individuals are in a state of high arousal when first confronting the task and do their best when encouraged. Once they fully understand and confront the complex task, then they may slip into a state of low arousal, to conserve energy and allow defocused attention or the unconscious mind to arrive at a solution that must be analyzed and doubted before it surfaces. In the final stage, creativity appears to be better served by negative valence, which is known to promote more in-depth, detail-oriented analytical thinking (Gasper & Clore, 2002). Therefore, our manipulations could have influenced creativity at different stages of the process, with positive valence–high arousal combination stimulating the creative process in the beginning and the negative valence–low arousal combination boosting the later, more analytical stages.

Regardless of the mechanisms through which creativity is achieved, it is clear that both arousal and valence components of emotion were involved in an integral fashion in this study. Simple arousal-based formulations, which claim that low arousal is associated with inspiration and high arousal with elaboration (e.g., Martindale & Hasenfus, 1978), do not provide a comprehensive account of the role played by emotion in the creative process. Likewise, simple valence-based formulations such as affect-as-prime do not sufficiently explain the complexity of our findings. For example, Isen et al. (1987) argued that, in most people, positive thoughts prime more accessible, related thoughts than negative thoughts. If this were true, then positive valence would have had a significant effect at all three levels of arousal, but our study found that it was effective only at high levels. Our data also failed to support Gasper's (2004) proposition that it is how a person interprets valence that affects the generation of original ideas, not the valence itself. We found that manipulated valence did make a difference at high and low levels of arousal, but in different directions.

Theoretically, particular combinations of the valence and arousal dimensions of emotion result in cognitive enhancement of capacity for creative thinking, particularly defocused attention and motivation to perform. Perhaps a discrete, rather than a dimensional, conceptualization of emotions (Ekman, 1992) may reveal that certain specific emotions (e.g., euphoria, depression) are better than others (e.g., contentment, anger) for stimulating creativity because they are particularly suited for inducing the kind of attention and/or motivation needed for a creative task.

Practical Implications

In practical terms, our study implies that after playing a videogame, those who are happy—and somewhat unexpectedly, those who are sad as well—tend to be more creative than those who are relaxed or angry. When one is highly aroused by playing a game, the energy acts as a catalyst, and the happy mood provides the encouragement to be creative. A negative mood, especially under conditions of low arousal, signals a different kind of energy—one that makes a person more analytical, which is also helpful for creativity.

For the designer, this means games meant for stimulating creativity ought to generate enough excitement to make the winners feel happy, but not so much that they lead to frustration in the event of a loss. The ideal game is one where the players either win excitedly or lose calmly. As corporations and the military begin to invest in game-based training and teachers explore games as a new medium for instruction, fostering creativity through game play could have important practical benefits to society. By understanding emotion's effect on creativity, innovative teachers may be better able to exploit the engagement potential of video games and other interactive media for learning. It is abundantly clear that today's students create media using pictures, sound, and text every day, but on their own terms after school to interact informally with each other, via video and computer games, cell phones, instant messages, and on social spaces like YouTube, Facebook, and Second Life. Embedded in all this informal communication is emotion and a high degree of engagement. Our findings suggest that the emotions generated when interacting in these venues can be quite influential in fostering creative expression, as has already been noted on several shared online spaces such as blogs and other online applications designed to showcase one's creative work (e.g., Flickr).

Limitations and Future Research Directions

Emotions are, in the real world, a combination of at least the two dimensions of arousal and valence, probably more. The problem of decay of the two manipulations was a concern during the design of this study. What might have happened if the order of the manipulations had been switched and the mood manipulation had come prior to manipulating arousal through assignment to different levels of arousal? Had the mood manipulation taken place first, instead of the level of arousal, there was concern that the negative mood condition, for example, might have both influenced and been overwhelmed by the experience of playing *Dance Dance Revolution.* As a physical video game, *Dance Dance Revolution* might have released endorphins, causing a more positive mood than normal; in addition, most students consider the experience of playing a video game pleasant and entertaining, which might also have altered the mood of players. As it is, when the mood manipulation was given, students appeared to project their positive or negative mood onto the person who gave them a good or bad grade. So, in this design, the grade was clearly the cause of the mood, and the administrator the object of it.

To avoid decay, if we were to redo the study, we might choose another type of video game, such as an interactive drama, that could deliver the independent variables of arousal and valence simultaneously. It would also be possible in such a game to build a creative task into the storyline of the game itself, which would house both the independent and dependent variables in one media form, instead of jumping back and forth between paper and pencil and electronic forms of media, as this study did.

From a theoretical perspective, researchers may want to further develop and enrich creativity theory as it relates to emotion. There is a clear need to explore further the mixed results of valence on creativity. Finally, investigating why and how the combined effect of arousal and valence is different for different aspects of creativity may lead to a more refined theoretical understanding of the role of emotion in creativity.

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