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The dynamic influence of emotions on game-based creativity: An integrated analysis of emotional valence, activation strength, and regulation focus

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ABSTRACT

Emotion has been identified as an important predictor of creativity, but little attention has been put on investigating how emotion, especially that considers regulation focus, may dynamically influence male and female students' creativity in game-based situations. To explore the dynamic relationship between various types of emotions and creativity during game playing, 266 college students were included and the Creativity Game-based Evaluation System (CGES) was developed in this study. Four types of emotions integrating perspectives of valence (positive vs. negative), activation (high vs. low), and regulatory focus (prevention vs. promotion) were investigated in this study: the positive-low activation-prevention emotion (P-L-Pre) (calm and relaxed), the positive-high activation-promotion emotion (P-H-Pro) (happy and elated), the negative-high activation-prevention emotion (N-H-Pre) (nervous and anxious), and the negative-high activation-promotion emotion (N-H-Pro) (frustrated and angry). The results revealed that, although there was a slight gender difference in game-based creativity, the prediction patterns of emotions in game-based creativity were very similar among participants with different genders. Specifically, emotions during game playing can better predict creativity than those of the baseline; moreover, the P-H-Pro emotion can facilitate performance on creativity, whereas the N-H-Pro emotion can decrease creativity performance. Thus, providing appropriate challenges to induce highly-activated and promotion-focused positive emotions are critical for the success of games designed to improve creativity.

1. Introduction

Games have been defined as an immersive, voluntary, and enjoyable activity in which a challenging goal is pursued (Freitas & Oliver, 2006; Kinzie & Joseph, 2008). Many studies have found that educational games can enhance learning motivation and learning outcomes (e.g., Dickey, 2011; Hung, Hwang, Lee, & Su, 2012; Sung & Hwang, 2013). On the other hand, creativity is an important educational goal in this rapidly changing society. Despite substantial research on creativity in recent decades, studies that integrate creativity and games are still limited. Among the game-free creativity research, emotions are one of the most influential factors on creativity performance. However, the findings on how emotions influence creativity are not consistent. Some studies suggest that positive emotions can facilitate creativity (e.g., Forgeard, 2011; Hutton & Sundar, 2010; Isbister, 2011), whereas other studies suggest that negative emotions can enhance creativity (e.g., Hirt, Devers, & McCrea, 2008; Jones & Kelly, 2009). Moreover, some studies claim that in addition to valence (positive vs. negative), the arousal level of emotions is important (De Dreu, Baas, & Nijstad, 2008; Zenasni & Lubart, 2008). More recently, researchers have suggested that valence, activation level, and regulation focus (prevention vs. promotion) all need to be taken into account when exploring the influence of emotions on creativity (Baas, De Dreu, & Nijstad, 2008; Yeh, 2012).

To date, only a few studies have investigated the relationship of flow experience or enjoyment (positive emotions) and creativity

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(Boyle, Connolly, & Hainey, 2011; Chang, Wu, Weng, & Sung, 2012); few studies have focused on understanding the relationship between various types of emotions and creativity in game-based learning or their dynamic relationship during game playing, not to mention those explore gender differences. It has been suggested that there are gender difference in creativity performance (Lin, Hsu, Chen, & Wang, 2012; Naderi, Abdullah, Aizan, Sharir, & Kumar, 2009), gaming (Homer, Hayward, Frye, & Plass, 2012; Yang & Chen, 2010), and emotions (Simon, 2014; Tolegenova, Kustubayeva, & Matthews, 2014; Zhao, Zhang, & Zheng, 2014). Thus, this study mainly aimed at exploring the dynamic relationship between various types of emotions and creativity in game-based situations from an integrated perspective of emotions. Meanwhile, gender differences in such a dynamic relationship were also examined.

1.1. Game-based learning and creativity

Numerous definitions of creativity have been proposed (e.g., Kampylis, Berki, & Saariluoma, 2009; Zeng, Proctor, & Salvendy, 2011) over the past six decades. In a review article, Hennessey and Amabile (2010) suggested that creativity involves the development of a novel product, idea, or problem solution that is valuable to the individual and/or the larger social group. Yeh (2011) also proposed that creativity is a process of producing original and valuable products within a specific cultural context. To ensure originality or novelty, some researchers (Dineen, Samuel, & Livesey, 2005) have claimed that appropriateness and convergent thinking, as well as divergent and productive thinking, are necessary for creativity. In cognitive psychology, many researchers use insight problems to test creativity, as it enables researchers to experimentally examine the process of creativity within a relatively short time period (Abraham & Windmann, 2007). Insight problems, which typically include open problems and closed solutions, involve restructuring a problem before the problem can be solved (Abraham & Windmann, 2007). Therefore, this study employed insight problems to measure an individual's creativity during playing games.

Recently, game-based learning has attracted researchers' attention, as it is effective in engaging players in learning (Bayliss, 2007; Prensky, 2003). Games usually include clear objectives, and they often provide tasks with multiple difficulty levels to adapt to the prior knowledge and skills of learners; therefore, games are considered as an effective educational tool (Gentile & Gentile, 2008). As information technology is rapidly developing, games have become interactive; they provide a complete playing environment that motivates learners through fun, challenge, and instant visual feedback (Mitchell & Savill-Smith, 2004).

Although some researchers (Kiili, 2005; MacDonald, Stodel, Farres, Breithaupt, & Gabriel, 2001) have suggested that games can support the learning of creativity, few researchers have developed games for evaluating or enhancing creativity. Faiola, Newlon, Pfaff, and Smyslova (2012) found that game-based learning can enhance learning experience while promoting exploration and creativity. In the same vein, Michalewicz and Michalewicz (2007) found that puzzle-based learning can support problem-solving skills and creative thinking. Thus, games can be employed to enhance the development of creativity and motivate the learner to solve problems through his or her interactions with game scenarios; during the process, the learner may link the abstract concept to the concrete game experience in an attempt to solve a problem (Lenga, Alib, Mahmudb, & Baki, 2010). However, the role of emotions has not been investigated in these game-based studies.

1.2. Emotions and creativity in game-based learning

1.2.1. Emotions and creativity

Among the influential factors on creativity, emotion has been the most widely studied predictor of creativity (Baas et al., 2008). Many studies have examined the relationships between emotions and creativity from the perspective of valence (positive emotions vs. negative emotions). Some findings suggest that a positive emotional state facilitates creativity, as it enhances cognitive flexibility and association network (Baas et al., 2008; Forgeard, 2011; Fredrickson, Cohn, Coffey, Pek, & Finkel, 2008; Hutton & Sundar, 2010; Subramaniam, Kounios, Parrish, & Jung-Beeman, 2009). In contrast, other findings suggest that a negative emotional state enhances creativity, as it indicates that the current situation is problematic and therefore motivates actions to solve the problem (Baruch, Grotberg, & Stutman, 2008; Carlsson, 2002; Hirt et al., 2008; Jones & Kelly, 2009; Zenasni & Lubart, 2009). Other findings suggest that the positive and negative emotions may exist simultaneously and facilitate creativity when the emotion is appropriately used and when the situation is novel (Fong, 2006; Kaufmann & Vosburg, 1997).

Researchers have also investigated the relationship between emotions and creativity from the perspective of arousal. While some findings suggest that highly aroused negative emotions decrease the production of original ideas (Zenasni & Lubart, 2008), other findings suggest that activating moods (e.g., angry, happy) lead to more creativity than deactivating moods (De Dreu et al., 2008).

These inconsistent findings may indicate that examining the relationship between emotions and creativity from the unidimensional (valence or activation level) perspective may oversimplify their relationship. The three-dimensional theory of emotion (Baas et al., 2008) may help to illuminate the complex relationship between emotions and creativity. The three dimensions include hedonic tone (positive vs. negative), level of activation (activating vs. deactivating), and regulatory focus (promotion vs. prevention). According to Baas et al. (2008), emotional states that are related to a promotion focus (e.g., anger, happiness) expand attentional scope and thus facilitate creative performance, whereas emotional states that are associated with a prevention focus (e.g., fear, relaxation) constrict attentional scope and therefore impede creative performance.

According to the social cognitive perspective, self-regulation learning includes three cyclist and interactive phase: (1) forethought: it involves task analysis and self-motivation beliefs; (2) performance: it involves self-control and self-observation; and (3) self-reflection: it involves self-judgment and self-reaction. During the process of self-reaction, feelings of self-satisfaction and emotion may motivate efforts to learn. Self-reaction may also involve adaptive inferences which influence approaches for subsequent learning. Moreover, the self-reflection reactions influence the goal setting, planning, and motivational beliefs regarding further efforts to learn in the forethought phase (Zimmerman, 2011). These arguments explain the importance of including regulation focus in emotions.

1.2.2. Emotions, and game-based creativity

It has been suggested that emotion is related to learning achievement in game-based learning (Chu, Hwang, Tsai, & Tseng, 2010; Fu, Su, & Yu, 2009). The Understanding of players' emotions, such as subjective feelings, anxiety, and enjoyment, has recently attracted attention from researchers (Fu et al., 2009; Jennett et al., 2008). Some researchers (Boyle et al., 2011) have claimed that enjoyment is the main emotion experienced when playing games. Thus, a measure of enjoyment in educational games

that assesses eight dimensions of enjoyment has been developed. The measured dimensions are as follows: immersion, social interaction, challenge, goal clarity, feedback, concentration, control, and knowledge improvement (Fu et al., 2009). Similarly, it has been suggested that games are designed to generate a positive emotion in players and that games are most successful and engaging when they facilitate the flow experience (Kiili, 2005). "Flow experience" is a highly enjoyable state of consciousness that occurs when a player's skills match the challenges; it involves a feeling of enjoyment and psychological immersion, energized focus, and involvement is often accompanied by positive emotions or a sense of pleasure (Faiola et al., 2012). Previous research has shown that the flow state has a positive impact on learning (Faiola et al., 2012; Kiili, 2005) and that it should be taken into account when designing digital games. Empirical studies (Chang et al., 2012; Faiola et al., 2012) have found that game-based learning can facilitate flow experience and problem-solving.

However, some researchers have suggested that negative emotions (e.g., anxiety) may strengthen players' enjoyment while they are playing fast-paced games (Jennett et al., 2008). Some studies have also examined a variety of physiological correlates of emotions in the game. For example, Baldaro et al. (2004) demonstrated that increases in blood pressure changes heart rate when playing games. Psychological studies, however, have inconsistent viewpoints toward how negative emotions influence creativity. For example, De Dreu et al. (2008) suggested that stressors may increase emotional arousal, which further enhances the use of creative thoughts and motivates persistence toward finding solutions. On the other hand, Byron, Khazanchi, and Nazarian (2010) found severe stressor may hinder creativity from a meta-analysis study. Accordingly, emotions may have strong influences on game-based creativity, regardless of influence directions.

1.2.3. Gender differences in emotions and game-based creativity

The role of gender in creativity has been explored to determine whether males and females differ in performance of creativity. To date, related findings are inconclusive (e.g. Baer & Kaufman, 2008; Naderi et al., 2009; Runco, Cramond, & Pagnani, 2010). Moreover, little empirical evidence of gender differences on domain-general creativity has been found (Abraham, 2015). However, in a recent cognitive neuroscience study, it was found that there were gender differences of changes in the power of bioelectric potentials, suggesting that the neurophysiological mechanisms of creativity are different in men and women (Volf & Tarasova, 2013).

In game-based situations, few studies have investigated gender differences in creativity. However, some studies have found gender differences in attitudes and strategies during gaming. In a sharing game, Zin, Escobal, Esteves, and Goyos (2015) found that males chose more optimized alternatives than females in the economic sense. In an investigation of attitudes for computer games, it was found that males had a more positive attitude toward using computer games for learning, demonstrated greater confidence in using computer games, and showed more enjoyment in the activities (Liu, Lee, & Chen, 2013). In the same vein, it was found that boys reported greater feelings of reward related to success in games (Hamlen, 2010). Such differences in attitudes and strategies may results in varied levels of creative performances.

As for gender differences in emotions, sociological research have consistently found that men report more frequent positive and less frequent negative feelings than women (Simon, 2014). Along the same line, it was found that girls experienced more anxiety and greater difficulties regulating their negative emotions than boys, suggesting that females have greater non-acceptance of negative emotions and less access to effective emotion regulation strategies than boys (Bender, Reinholdt-Dunne, Esbjørn, & Pons, 2012). On the contrary, it was found that females were more likely to use emotion regulation strategies than males (Zhao et al., 2014). Such inconsistent findings of gender differences bring about an interesting question: Are there gender differences with regard to how emotions influence game-based creativity?

2. The present study

As aforementioned, researchers have seldom focused on the role of emotions in game-based learning, especially negative emotions. In studies investigating positive emotions, most have focused on enjoyment and the flow experience. To date, no studies have examined the relationship between the three dimensions of emotions (valence, arousal, and regulation focus) and creativity in games. However, a recent study (Yeh, 2012) found that highly activated positive emotions with a promotion focus facilitated creativity and that highly activated negative emotions with a promotion focus hindered creativity. Moreover, games are interactive, and strong emotions usually occur during the game, especially when players are aware of the difficulties of challenges (Baldaro et al., 2004; Faiola et al., 2012). Thus, player's emotions may change and dynamically influence their creativity during the game playing process based on the challenges they perceive. On the other hand, although gender differences may exist in game-based creativity and emotions, and therefore, bring about different interaction patterns, the robust predictive power of emotions on creativity found in past studies seem to favor the argument that the dynamic influence patterns between emotions and game-based creativity should be similar across genders. Accordingly, this study used college students as participants and aimed to explore how different types of emotion before and during the game influenced their creativity; meanwhile, gender differences were examined in an exploratory manner. The following hypotheses were proposed in this study:

H1. Positive emotions during the game, particularly emotions with a high level of activation and a regulation focus of promotion, positively predict both male and female college students' performance on game-based creativity.

H2. Negative emotions during the game, particularly emotions with a high level of activation and a regulation focus of promotion, negatively predict both male and female college students' performance on game-based creativity.

3. Methods

3.1. Participants

All experimental tasks and data collection were conducted via a computer system. Two hundred and sixty-six undergraduates (77 males and 189 females) participated in this study. The participants' mean age was 19.94 years ($SD = 2.498$ years). All participants filled out an informed consent form before the experiment and received approximately $10 USD for participation.

3.2. Instruments

3.2.1. The framework and the characteristics of the CGES

The main instrument employed in this study was the *Creativity Game-based Evaluation System (CGES)*. In this study, the CGES was developed to evaluate game-based creativity using web techniques, multi-agent systems, and a rule-based agent system. It was composed of three agents: the User Interface Agent which was employed to collect personal information, the Creativity Game

Agent which was employed to evaluate creativity, and the Questionnaire Agent which was used to measure emotions (see Fig. 1). The main characteristics of the CGES included great convenience and portability, efficient evaluation, and cross-domain integration (see Table 1).

3.2.2. Creativity game agent

The CGES included a series of insight problem tasks that were adapted from the Situation-based Creativity Tasks (SCT) to evaluate the participants' game-based creativity in this study. The SCT was developed by Flash. The original SCT included three situation- and game-based insight problem scenarios which have been successfully employed to measure creativity (Lin, Yeh, Hung, & Chang, 2013; Yeh, Lai, Lin, Lin, & Sun, 2015).

It has been suggested that creativity is sparked when players engage in the process of problem solving and that digital games result in the exploration of different combinations and abilities to solve problems in creative ways (Hsiao, Chang, Lin, & Hu, 2014). Based on past findings with regard to effective game design and flow experiences (Chang et al., 2012; Faiola et al., 2012; Hsiao et al., 2014; Kiili, 2005; Niederhauser & Stoddart, 2001), the creativity games employed in this study included the following characteristics: (1) solving complex problems in a structured context, in which tools were provided to assist players to solve problems; (2) containing clear goals and specific feedback; (3) containing appropriate challenges and autonomy to enhance positive emotions; and (4) enhancing attention and immersion to increase concentration level and emotional arousal. Specifically, the goal of the SCT was to escape from the living room, the kitchen, and the bathroom. Each scenario of the SCT consisted of 10 insight problems, and the problems could be solved with different paths. In this study, only the living room and the kitchen game scenarios were included in the Creativity Game Agent due to time constraints. In each of the game scenarios, two instruments provided in the situation had to be correctly combined in order to solve each of the problems (see Fig. 2 for the example of problem solving). Immediate feedback was given with regard to whether the answer was right or wrong. Correct answers would be also shown on the right column so that the participant could know the progress of problem solving. In these games, an incorrect answer received 0 points and a correct answer received 1 point. The highest total score was 20 points (10 points in each game scenario). The time limit of 10 min for each of the game scenario and a count-down clock were set to enhance attention and immersion.

3.2.3. The questionnaire agent

The aim of the Questionnaire Agent was to collect data on the participants' emotions. In this study, the Inventory of Three-dimensional Emotions (I3E) was employed to measure the participants' emotions in this study (Yeh, Lin, Yeh, & Lin, 2012). The I3E included three dimensions: valence (positive vs. negative), activation (high vs. low), and regulatory focus (prevention vs. promotion). The I3E was composed of 8 types of emotions, each of which included 2 items (see Table 2). Each item was scored from 1 to 4 points, representing “highly disagree” to “highly agree”. A confirmatory factor analysis (CFA) indicated that both the negative emotion model and the positive emotion model have good construct validity; moreover, Cronbach's α for the I3E is .839 (Yeh et al., 2012). Based on the nature of our games, the following four types of emotions were more related and therefore were employed in this study: the positive-low activation-prevention emotion (P-L-Pre) (calm and relaxed), the positive-high activation-promotion emotion (P-H-Pro) (happy and elated), the negative-high activation-prevention emotion (N-H-Pre) (nervous and anxious), and the negative-high activation-promotion emotion (N-H-Pro) (frustrated and angry). Based on the data of this study, the Cronbach's α for the four types of emotions were .84, .76, .66, and .82.

3.3. Procedures

This study used desktop computers to collect data. All study procedures were approved by the University's Institutional Review Board (IRB). To increase validity and reliability, the data were collected individually in the laboratory. It took approximately

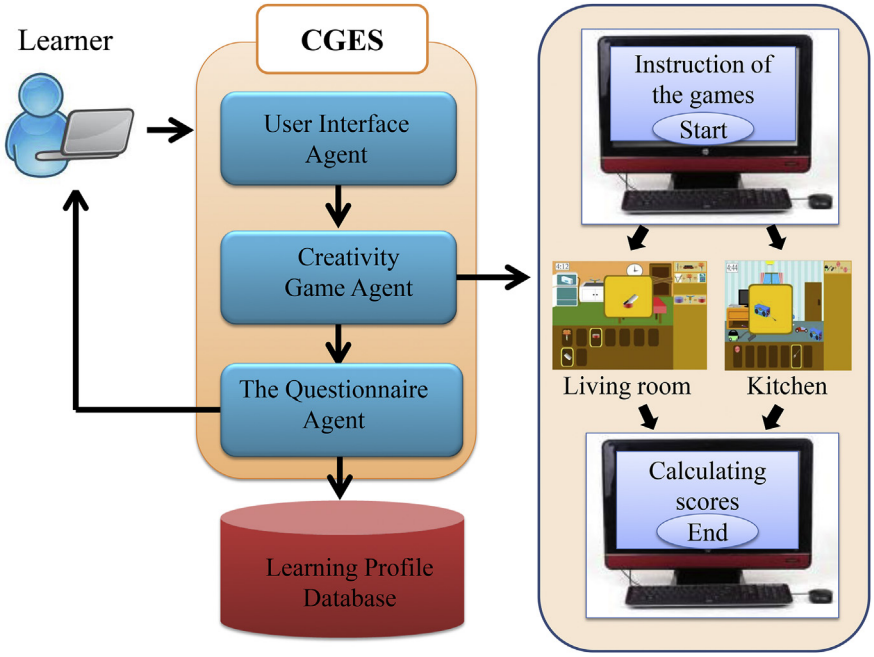

Fig. 1. The structure of the CGES.

Table 1
The characteristics of the CGES.

Convenience and portability
• The CGES was developed based on web techniques; thus, learning materials are not constrained by locations. Learners can learn anywhere on web-based learning systems.
• The CGES was developed via PHP, Net, and JavaScript, which makes the system adaptable to mobile devices (e.g., smart phones and electronic pads).
Efficient evaluation
• Multi-agents were employed to modulate the learning environment with different types of agents, which enabled different routes to solve problems.
• Learning performance was efficiently evaluated through multi-agents based on the Web framework.
Cross-domain integration
• The theories of creativity and cognitive psychology were employed as the theoretical bases of the CGES.
• The animation technology and the techniques of knowledge management were used to support the game-based environment.

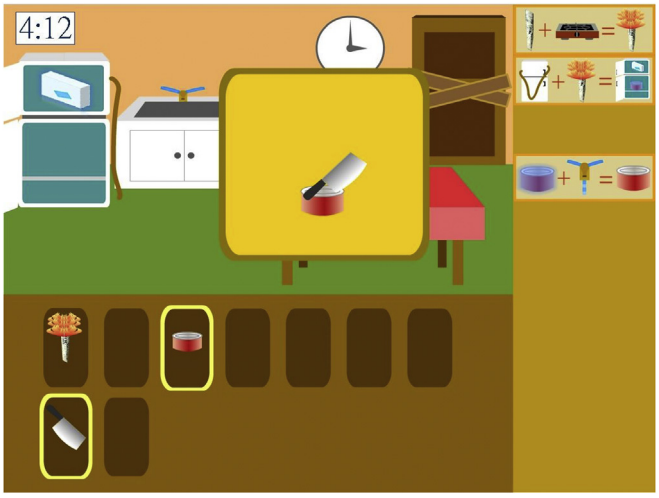

Fig. 2. An example screen in the game.

40 min. The experimental procedures were as follows:

- Step 1: The learner registered personal information with the User Interface Agent.
- Step 2: An instruction screen was displayed after the system verified the identity of the user. To ensure that the learner completely understood the procedures for how to complete the tasks in the CGES, as well as to increase the reliability and validity of the collected data, an instruction subsystem was designed in the CGES.
- Step 3: The Questionnaire Agent collected the baseline data of emotions (Time 1).
- Step 4: The Creativity Game Agent prompted the learner to solve problems in the Living room game scenario.
- Step 5: The Questionnaire Agent collected the data of emotions during game playing (Time 2).
- Step 6: The Creativity Game Agent prompted the learner to solve problems in the kitchen game scenario.
- Step 7: The learner received a debriefing.

4. Results

4.1. Preliminary analysis

Preliminary analysis showed that there was a gender difference in performance on creativity games, $F(1, 264) = 4.997$, $p = .026$, $\eta^2_p = .019$; specifically, the males outperformed the females ($M = 9.27$ vs. 7.59). On the other hand, no gender differences were found on the four types of emotions with regard to the changes between Time 1 (before the games) and Time 2 (during the games), $F(1, 264) = .181$, 3.541, .442, and 1.324 ($ps > .05$) for P-L-Pre (calm and relaxed), P-H-Pro (happy and elated), N-H-Pre (nervous and anxious), and N-H-Pro (frustrated and angry), respectively. To clearly depict the dynamic relationship between emotion and creativity, we conducted the following analyses with each gender.

4.2. The effect of emotions on creativity

To examine whether there were dynamic interactions between emotions (P-L-Pre, P-H-Pro, N-H-Pre, N-H-Pro) and creativity in games, we used the Time 1 emotion as the baseline and used the Time 2 emotion as the comparison line to examine how emotions influence game-based creativity at different time points. The means and standard deviations of males and females are shown in Fig. 3 (a) and Fig. 3 (b).

4.2.1. Positive emotions and game-based creativity

Regression analyses showed that the positive emotions at Time 1 (P-L-Pre_{T1} and P-H-Pro_{T1}) could not collectively predict either the male or the female participants' creativity, $Rs = .244$ and .242, $ps > .05$. However, the positive emotions at Time 2 (P-L-Pre_{T2} and P-H-Pro_{T2}) could collectively predict both the male and the female participants' creativity, $Rs = .606$ and .350, $ps = .000$, respectively (see Table 3).

T-tests of βs found that the positive emotion of P-L-Pre_{T1} (calm, relaxed) before the game could predict the female participants' creativity, $t = 3.347$, $p = .001$. Moreover, the positive emotion of P-H-Pro_{T2} (happy and elated) during the game powerfully predicted both the male and the female participants' creativity, $ts = 6.553$ and 4.995, $ps = .000$ (see Table 4).

Table 2
The construct of the I3E.

Positive				Negative			
Low-activation		High-activation		Low-activation		High-activation	
Prevention focused	Promotion focused	Prevention focused	Promotion focused	Prevention focused	Promotion focused	Prevention focused	Promotion focused
Calm	Warm	Secure	Happy	Isolated	Sad	Tense	Angry
Relaxed	Lively	Trusting	Elated	Exhausted	Disappointed	Fear	Frustrated

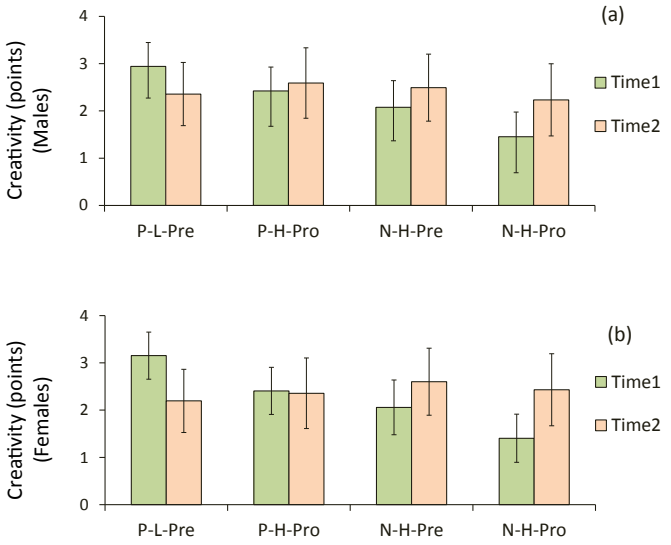

Fig. 3. The means and standard deviations of male and female creativity in different emotion groups. *Note*. P-L-Pre: Positive-Low activation-Prevention (calm and relaxed). P-H-Pro: Positive-High activation-Promotion (happy and elated). N-H-Pre: Negative-High activation-Prevention (nervous and anxious). N-H-Pro: Negative-High activation-Promotion (angry and frustrated).

Table 3
Model summary for predicting creativity via positive emotions at Time 1 and Time 2.

Gender	*R*	R^2	Adjusted R^2	Change statistics			
				F change	*df*1	*df*2	Sig. *F* change
Time 1							
Male	.173	.030	.004	1.297	2	74	.279
Female	.242	.059	.049	1.286	2	186	.279
Time 2							
Male	.606	.367	.350	21.471***	2	74	.000
Female	.350	.123	.113	12.995***	2	186	.000

***$p < .001$.

4.2.2. Negative emotions and game-based creativity

Regression analyses showed that the negative emotions at Time 1 (N-H-Pre_{T1} and N-H-Pro_{T1}) could not predict either the male or the female participants' creativity, *Rs* = .184 and .117, *ps* > .05.

Table 5
Model summary for predicting creativity via negative emotions at Time 1 and Time 2.

Gender	*R*	R^2	Adjusted R^2	Change statistics			
				F change	*df*1	*df*2	Sig. *F* change
Time 1							
Male	.184	.034	.008	1.297	2	74	.279
Female	.117	.014	.003	1.286	2	186	.279
Time 2							
Male	.459	.210	.189	9.862***	2	74	.000
Female	.316	.100	.090	10.319***	2	186	.000

***$p < .001$.

However, the negative emotions at Time 2 (N-H-Pre_{T2} and N-H-Pro_{T2}) could collectively predict both the male and the female participants' creativity, *Rs* = .459 and .316, *ps* = .000 (see Table 5).

T-tests of βs found that the negative emotion of N-H-Pro_{T2} (angry and frustrated) during the game powerfully predicted both the male and the female participants' creativity, *ts* = −4.066 and −4.268, *ps* = .000 (see Table 6).

5. Discussion

Preliminary analysis showed that the males outperformed the females on game-based creativity. This finding is not consistent with previous findings that indicated females' performance on creativity measures is better than males (Baer & Kaufman, 2008; Naderi et al., 2009) and that games may have positive effects on engaging learning experiences for female players (Dickey, 2006). However, the results here lend support to the findings that the neurophysiological mechanisms of creativity are different in men and women (Volf & Tarasova, 2013) and that males have better performance on insight problem solving tasks (Lin et al., 2012); the creativity tasks employed in this study are, in essence, insight problem-solving tasks. In studies of games, researchers have found that males spend more time in playing video (Homer et al., 2012), derive more enjoyment from the computer games (Liu et al., 2013), and get more success-related rewards in games than females (Hamlen, 2010), which contribute to their better performance than females within digital games. Moreover, strategies employed during gaming also help interpreting gender differences in the creative performance (Abraham, 2015). It has been found that male students

Table 4
Coefficients of regression analysis for predicting creativity via positive emotions at Time 1 and Time 2.

	Unstandardized coefficients		Standardized coefficients		
	B	Std. error	β	*t*	Sig.
Time 1					
Male					
(Constant)	4.827	5.313		.908	.367
P-L-Pre_{T1}	−.067	1.295	−.006	−.052	.959
P−H-Pro_{T1}	1.917	1.293	.172	1.482	.143
Female					
(Constant)	1.953	2.826		.691	.490
P-L-Pre_{T1}	2.759	.825	.248	3.347***	.001
P−H-Pro_{T1}	−1.274	.824	−.115	−1.547	.124
Time 2					
Male					
(Constant)	.565	2.341		.241	.810
P-L-Pre_{T2}	−1.587	.819	−.187	−1.937	.057
P−H-Pro_{T2}	4.805	.733	.633	6.553***	.000
Female					
(Constant)	2.478	1.514		1.637	.103
P-L-Pre_{T2}	−.579	.614	−.070	−.943	.347
P-H-Pro_{T2}	2.707	.542	.371	4.995***	.000

***$p < .001$.

Table 6
Coefficients of regression analysis for predicting creativity via negative emotions at Time 1 and Time 2.

	Unstandardized coefficients		Standardized coefficients		
	B	Std. error	β	*t*	Sig.
Time 1					
Male					
(Constant)	6.962	2.724		2.556*	.013
N-H-Pre$_{T1}$	1.888	1.209	.187	1.562	.122
N-H-Pro$_{T1}$	−1.109	1.306	−.102	−.849	.398
Female					
(Constant)	9.496	1.637		5.803***	.000
N-H-Pre$_{T1}$	−1.177	.735	−.123	−1.601	.111
N-H-Pro$_{T1}$	.365	.837	.034	.436	.663
Time 2					
Male					
(Constant)	15.492	2.227		6.956***	.000
N-H-Pre$_{T2}$	.952	1.018	.119	.935	.353
N-H-Pro$_{T2}$	−3.846	.946	−.518	−4.066***	.000
Female					
(Constant)	12.332	1.692		7.288***	.000
N-H-Pre$_{T2}$	.575	.694	.067	.828	.409
N-H-Pro$_{T2}$	−2.567	.601	−.345	−4.268***	.000

*** $p < .001$.

are more likely to embrace a manipulation-oriented information processing approach, a command strategy for executing tasks, and a competitive social comportment when using computer games. Such strategies may help males to get high scores in games (Liu et al., 2013). On the other hand, the insignificant gender differences in emotion changes suggest that the male and female college students do not differ in experiencing the emotions and using emotion regulation strategies during the game playing, which are not consistent with past findings (Bender et al., 2012; Zhao et al., 2014).

In this study, we did regression analyses separately based on the male and female samples. The findings suggest that although there is a slight gender difference in game-based creativity, the prediction power and pattern of emotions in game-based creativity are very similar among participants with different genders. Specifically, emotions with a high activation level and a promotion focus during the game can predict performance on game-based creativity across genders; however, the influence direction is opposite with regards to emotional valence (positive emotions vs. negative emotions). In other words, while the positive-high activation-promotion emotions (happy and elated) during the game facilitate creativity, the negative-high activation-promotion emotions (angry and frustrated) hinder creativity. The r^2 values also suggest that the prediction power of the positive-high activation-promotion emotions are greater than those of the negative-high activation-promotion emotions. These findings support our hypotheses that emotions during the game, particularly the emotions with a high level of activation and a regulation focus of promotion, can predict college students' performance on game-based creativity. The results support that the three-dimensional theory of emotion (Baas et al., 2008) can depict the complex relationship between emotions and creativity, as well as that a positive emotional state facilitates creativity as it enhances cognitive flexibility and the association network (Baas et al., 2008; Davis, 2009; Forgeard, 2011; Hutton & Sundar, 2010; Subramaniam et al., 2009). Moreover, the findings are in line with the social cognitive perspective of self-regulation learning and suggest that positive self-reactions are self-initiated, social, and motivational as well as such processes facilitate task interest, task choice, and persistence (Zimmerman, 2011). In addition, the results lend support to the findings that flow experience and enjoyment can facilitate creativity (Boyle et al., 2011; Chang et al., 2012) and highly activated emotions lead to more creativity than do deactivating emotions (De Dreu et al., 2008). Accordingly, the CGES developed in this study can serve as an effective evaluation system for creativity and its underlying mechanisms can enhance the flow experiences and, further facilitate creativity.

The findings in this study also illustrate the dynamic influence of emotions on game-based creativity, which lends support to our hypothesis. Specifically, we found that the overall baseline emotion did not have a significant influence on subsequent creativity in games. However, as the game progresses, all participants' negative emotions, especially those with a high activation-promotion focus (angry and frustration), increased gradually. On the other hand, the influence of positive emotions, especially those with a high activation-promotion focus (happy and elated), on game-based creativity also increased to a significant level. These findings suggest that there are dynamic interactions between the players and the game. Moreover, the increase of highly-activated and promotion-focused negative emotions indicates that great challenges have been provided in the creativity games. What's more, the increasing influences of highly-activated and promotion-focused positive emotions on creativity suggests that when challenges can be overcome, positive emotions can be induced, which further enhances the player's creativity performance. These findings are in line with the claims that challenges can foster creativity and proactive actions (Baer & Oldham, 2006; Kangas, 2010; Ohly & Fritz, 2010). In games, players are required to overcome the challenges provided through generating solutions in the ideation loop. “Win” experiences is a critical process that keeps players engaged and moving forward in a game (Starks, 2014). According to the Geneplore model (Ward, Smith, & Finke, 1999), creative activities can be described as an initial generation of candidate ideas or solutions followed by extensive exploration of those ideas. Therefore, players' creativity can be enhanced by overcoming the challenges in games (Kiili, 2005) and the “win” experiences. This study also suggests that when the challenges cannot be conquered, highly activated negative emotions with a promotion focus can be induced, which may further hinder creativity performance. A previous study (Hirt et al., 2008) suggests that negative emotions motivate actions to solve problems. In contrast, the current findings suggest that the perceived feeling of negative emotions may decrease self-confidence and further hinder creativity. Thus, in a game-based creativity evaluation system, it is very important to provide appropriate challenges to increase highly-activated and

promotion-focused positive emotions.

6. Conclusions, limitations, and suggestions

As games are commonly played among the young generation in developed countries, it is important to determine how to transform strong learning motivation and passion in games into educational resources. Because creativity is one of the most important abilities to succeed in our technological and changing society, this study developed a game-based evaluation system for college students and investigated from an integrated perspective to explore how different types of emotions may influence creativity during game playing. The findings in this study provide important insights and implications for games designed to evaluate or improve creativity. The main findings in this study suggest that the influence of emotions on game-based creativity is dynamic; more specifically, emotions during game playing can better predict creativity than those of the baseline. Moreover, highly-activated positive emotions with a promotion focus can facilitate creativity performance, whereas highly-activated negative emotions with a promotion focus can decrease creativity performance. Accordingly, providing appropriate challenges to induce such positive emotions, as well to decrease such negative emotions, are critical for the success of games designed to improve creativity. To achieve this goal, complex problem solving, clear goal setting, immediate and specific feedback, autonomous decision making for problem solving, appropriate challenges for emotional arousal, win and flow experiences, and sense of immersion, should be considered simultaneously.

In this study, emotions were not manipulated. Further studies should aim to induce different types of emotions during game playing and investigate whether the dynamic interaction between emotions and creativity may differ across the manipulations. Moreover, the threshold of challenges may differ among players; future studies can design games for evaluating individual differences and design a personalized game-based learning system for improving learners' creativity.

Moreover, it was found that males favored the massively multiplayer online role-play games and females preferred party games (Procci, James, & Bowers, 2013). It was also found that males had greater confidence in controlling computer games and when playing a new game or a difficult game, females required more task-related supports to build competence and confidence (Liu et al., 2013). This study did not include different types of games, nor provide extra supports to the female participants. Further studies can consider these components when designing games for improving creativity.

Finally, for students to become creative, teachers should be able to provide a culture that values creativity (Craft, 2005). Game-based learning provides challenging experiences that enhance learners' intrinsic motivation and offer opportunities for authentic learning (Frossard, Barajas, & Trifonova, 2012). Teachers are encouraged to collaboratively design their own game-based learning scenarios, especially those tailored to their teaching contexts and student needs.

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