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Enhancing creativity: Proper body posture meets proper emotion

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ABSTRACT

This study tested whether compatibility or incompatibility between body posture and emotion was beneficial for creativity. In Study 1, participants were asked to solve the Alternative Uses Task (AUT) problems when performing open or closed body posture in positive or negative emotional state respectively. The results showed that originality of AUT performance was higher in the compatible conditions (i.e., open-positive and closed-negative) than in the incompatible conditions (i.e., closed-positive and open-negative). In Study 2, the compatibility effect was replicated in both the AUT and the Realistic Presented Problem test (i.e., RPP). Moreover, it was revealed that participants exhibited the highest associative flexibility in the open-positive condition, and the highest persistence in the closed-negative condition. These findings indicate that compatibility between body posture and emotion is beneficial for creativity. This may be because when the implicit emotions elicited by body posture match explicit emotions, the effects of emotions on creativity are enhanced, therefore promoting creativity through the flexibility or the persistence pathway respectively.

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1. Introduction

Creativity is defined as the ability to produce work that is novel (original and unique) and useful (Sternberg & Lubart, 1996; Runco & Jaeger, 2012). Previous studies revealed that emotions affected creative thinking, so did body motor actions. The current study aimed to examine whether and how body motor actions and emotions would integrate to influence creative thinking. Notably, divergent thinking (DT) and convergent thinking (CT) are two fundamental processes of creative thinking. The current study focused on DT, given that DT performance has been demonstrated to be a reliable predictor of creative potential (Runco & Acar, 2012).

1.1. Emotion, body motor action and creativity

Emotions influence creative thinking. The *dopaminergic theory of positive emotion* suggests that the increased dopamine level in positive emotional states could improve the selection of or the switching among alternative cognitive sets, therefore enhancing creativity (Ashby & Isen, 1999; Ashby, Valentin, & Turken, 2002). The *affect as information model* suggests that positive emotions signal a satisfactory and safe environment, which promotes simplifying heuristics or "loose" processing, and benefits creativity as a result (Fiedler, 1988, 2000; Schwarz, 1990, 2002). Recently, the *dual pathway to creativity model* (De Dreu, Baas, & Nijstad, 2008) suggests that both positive and negative emotions could exert positive impacts on creativity. This model assumes that there are two pathways to creative performance, namely the flexibility pathway and the persistence pathway. Positive and negative emotions with high arousal influence creativity through flexibility and persistence pathways respectively. Specifically, positive emotions benefit creativity by enhancing cognitive flexibility; in this case, individuals break mental sets, reorganize cognitive structures, and generate various cognitive categories. Negative emotions benefit creativity by enhancing cognitive persistence; that is, individuals are perseverant in making effort on problems, think up ideas belonging to one category, and dig out more original ideas (Baas, Roskes, Sligte, Nijstad, & De Dreu, 2013; Nijstad, De Dreu, Rietzschel, & Baas, 2010).

Body motor actions also influence creative thinking. For instance, Slepian and Ambady (2012) showed that fluid arm movements led to enhanced creativity. This may be because cognitive processing is embodied in sensorimotor systems, thus fluid movements lead to fluid thinking, which benefits creative idea generation (Slepian & Ambady, 2012). In addition, it was revealed that arm flexion (compared with arm extension) improved insight problem solving and promoted original idea generation (Friedman & Förster, 2000, 2002). It suggests that arm extension or flexion give rise to bodily feedbacks associated with avoidance or approach respectively (Cacioppo, Priester, & Berntson, 1993), which triggers a local or global processing style to deal with the situation (Förster & Dannenberg, 2010; Kuschel, Förster, & Denzler, 2010). Global processing style would facilitate the ability to activate inaccessible conceptual representations and more abstract

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concepts (e.g., thinking of a brick as a "reddish substance"), which can trigger more remote concepts (e.g., "makeup") and thereby enhance performance in creativity tasks (Hao, 2010; Ward, 2008; Ward, Patterson, & Sifonis, 2004). A recent study demonstrated that the effects of arm postures on creativity were influenced by body positions (i.e., being seated or horizontal) (Hao, Yuan, Hu, & Grabner, 2014). This may be because in the horizontal body position, arm extension decreases the physical distance between the self and an object in the hand and represents an approach motor action, while arm flexion increases the distance and reflects an avoidance motor action. Thus, the associations of arm extension/flexion and approach/avoidance are reverse in being seated or horizontal body positions. As a result, arm flexion and extension in the horizontal position affect creative cognition in a reverse pattern compared to that in the seated position.

Body motor actions influence emotions. For instance, participants in the open body posture felt more confident and performed better on the cognitive tasks; whereas they felt lack of confidence and performed worse in the closed body posture (Briñol, Petty, & Wagner, 2009). Given that the open body posture led individuals to feel more confident and dominant, individuals' emotions were affected by social exclusion only when they took open posture rather than closed posture (Welker, Oberleitner, Cain, & Carré, 2013). A recent study demonstrated that in a relatively long period (i.e., 90 min), participants in the open posture reported more positive emotions, while those in the closed posture reported more negative emotions (Zabetipour, Pishghadam, & Ghonsooly, 2015). It suggests that open or closed body posture could serve as pleasant or unpleasant cues, eliciting implicit positive or negative emotions, which might reflect on changes in testosterone, feeling of power and tolerance of risk (Carney, Cuddy, & Yap, 2010).

1.2. Effects of psychological incompatibility or compatibility on creativity

Plenty of studies indicated that psychological incompatibility could facilitate creative thinking. For example, individuals with rational thinking styles showed better creative performance when instructed to solve problems using the intuitive problem-solving approach (i.e., incompatible condition) relative to using the rational problem-solving approach (i.e., compatible condition) (Dane, Baer, Pratt, & Oldham, 2011). Participants exhibited higher creativity when their pre-existing moods were incompatible with the induced emotions (e.g., low in depression vs. induced negative emotions), compared with they did in the compatible condition (e.g., low in depression vs. the induced positive emotions) (Forgeard, 2011). Participants showed higher category inclusiveness and acceptance to alternatives in the incompatible conditions (e.g., recall a happy event while frowning or a sad event while smiling) (Huang & Galinsky, 2011). A typical explanation for the incompatibility effect is that individuals in the incompatible states tend to interpret problem situation as nonstandard, which triggers set-breaking cognitive processes and improves the ability to combine usually unrelated ideas together, thereby enhancing creativity (Dane et al., 2011).

However, some studies showed that psychological compatibility might positively affect creative thinking. It was reported that positive emotions benefited creativity when tasks were framed as enjoyable and intrinsically rewarding, so did negative emotions when tasks were framed as serious and extrinsically rewarding (Martin, 2001; Martin & Stoner, 1996). This was referred as the context-dependent effect of mood, which suggests that participants in an emotional incompatible condition would stop the activity sooner than participants in a compatible condition (Martin, Ward, Achee, & Wyer, 1993; Zajusz-Gawędzka & Marszał-Wiśniewska, 2015). Thus, participants performed worse in emotional incompatible condition than emotional compatible condition. Furthermore, a meta-analysis showed that positive emotions benefited divergent thinking (DT), while negative emotions facilitated convergent thinking (CT) (Davis, 2009). Given DT led to more positive emotions whereas CT had the opposite effect (Chermahini & Hommel, 2012), the findings indicated that compatibility of emotional states and thought processes would benefit creativity. This may be because explorative processing strategy fostered by positive emotions would benefit DT performance, while detail-oriented processing strategy fostered by negative emotions would be advantageous when one seeks the optimized solutions to the CT tasks.

1.3. The present study

Based on the above literature review, it is an open question whether incompatibility or compatibility between body posture and emotion is more likely to be beneficial for creativity. Recall here that positive and negative emotions benefit creativity through the flexibility and the persistence pathways respectively (De Dreu et al., 2008). It is reasonable to infer that when body postures elicit implicit emotions that match individuals' explicit emotional states, this compatibility might enhance the effects of emotions on creativity; whereas when implicit and explicit emotions do not match or even are conflictive, such an incompatibility would neutralize the effects of emotions on creativity. However, there is an alternative prediction. That is, incompatibility of body postures and emotions might make people perceive problem situation as nonstandard, which would foster people to think in a different way than they usually do, therefore enhancing creativity.

To test the contradictory predictions aforementioned, we conducted two studies. In Study 1, participants were asked to watch short emotion-appropriate videos to induce positive or negative emotional state respectively. Then they solved creativity problems when performing the open or closed body posture. This design allowed us to compare the effect of body posture and emotion (i.e., posture-emotion) compatibility or incompatibility on creativity. In Study 2, we replicated findings of Study 1 in different creativity tasks and in different time duration of task performance. We also explored the cognitive mechanism underlying the effect of posture-emotion combination on creativity. In both Study 1 and Study 2, we measured the effortfulness in maintaining open or closed body posture after the experiment, in order to check whether effect of body posture on creativity was independent of the effect of effortfulness in maintaining the given posture. Moreover, we measured participants' feeling of power and enjoyment of the experimental tasks in Study 1 and Study 2, given that feeling of power has been found to influence creative cognition (Galinsky, Magee, Gruenfeld, Whitson, & Liljenquist, 2008; Gervais, Guinote, Allen, & Slabu, 2013; Sligte, De Dreu, & Nijstad, 2011), and so has enjoyment of the experimental task (Zenasni & Lubart, 2011). This allowed an assessment of whether the open and closed body postures influence creativity through inducing different feeling of power or enjoyment of the experimental task.

2. Study 1

In Study 1, we induced participants' positive or negative emotions, and then asked them to work on a creativity-demanding task with the open or closed body posture. The main hypotheses were as follow. First, creative performance in positive emotions would show no difference from that in negative emotions, given that positive and negative emotions benefit creativity through two different pathways, as suggested by the *dual pathway to creativity model*. Second, creative performance in the compatible conditions (i.e., open-positive and closed-negative) would be different from that in the incompatible conditions (i.e., open-negative and closed-negative). Notably, we cannot give precise predictions before experiment, because both compatible and incompatible conditions could potentially benefit creativity.

2.1. Participants

One hundred and sixty college students, whose majors were not psychology, participated individually in the study. A 2 (EMOTION: positive and negative) × 2 (POSTURE: open and closed) between-subject design was employed. Participants were randomly assigned into one of the four experimental conditions. The data of 11 participants were excluded from further analysis, because these participants did not hold the given body posture during task performance. One participant who was originally assigned into the closed-positive condition completed the task in the open-negative condition. Thus, the final sample consisted of 149 participants (89 males, 60 females; age ranged from 18 to 23 years old, $M = 20.34$, $SD = 2.13$). There were 41, 35, 36, and 37 participants in the open-positive, open-negative, closed-positive, and closed-negative conditions respectively. They were all native Chinese speakers with normal hearing, normal vision or corrected vision, and with no limb disability. Participants gave written informed consent prior to the experiment, and received approximately 1 US dollar for their participation after the experiment. The protocol of the experiment was approved by the Institutional Ethics Committee at East China Normal University.

2.2. Experimental task

The Alternative Uses Task (AUT) (Guilford, 1967) was used as the target task. It requires respondents to generate as many unusual or original uses as possible for common objects, such as a paperclip (e.g., "making a ring", "cleaning fingernails"). The AUT is a well-established test of creative potential (Guilford, 1967; Runco, 1991, 1999; Runco & Mraz, 1992). Performance on this task has been demonstrated to be a reliable predictor of actual, real-world creative performance (Runco & Acar, 2012).

2.3. Experimental procedure

First, participants were asked to watch videos to induce corresponding emotions (see details in Emotion Inductions). Then they were asked to solve two AUT problems (i.e., "brick" and "chopstick") in 6 min (3 min per problem), with a 15 s break between the two problems. The sequences of problems were balanced for all participants. In the instruction about how to solve the AUT problems, participants were encouraged to try their best to produce ideas that would be thought of by no one else, as suggested by Harrington (1975) and Torrance (1995).

Given that the arms were used to perform open or closed body posture, participants could not write down their answers. Thus, they orally reported the ideas one by one during the epoch of working on an AUT problem. The oral reporting of ideas was widely used in previous studies on DT tasks (Friedman & Förster, 2002; Hao, Yuan, Cheng, Wang & Runco, 2015; Hao et al., 2014; Oppezzo & Schwartz, 2014). Participants' oral responses for the AUT problems were recorded by a voice recorder and transcribed afterwards for further analysis.

In the open body posture, participants stood in front of a desk, with one leg in the front and the other on the back. Ten fingers were opened and the palms were put downward. The distance between palms was slightly wider than shoulders. Participants put the weight on the hands and the front leg. In the closed body posture, participants stood in front of a desk, with legs crossed and with arms crossed in front of the chest tightly (see Fig. 1). The open posture took up more space and the whole chest was open, while the closed posture took up less space and the whole chest was closed (Carney et al., 2010).

2.4. Emotion inductions

Participants watched short emotion-appropriate videos to induce corresponding emotions as in previous studies (Forgas & East, 2008; Forgeard, 2011; Hao, Yuan, Cheng, Wang & Runco, 2015; Phillips, Bull, Adams, & Fraser, 2002; Rotteveel & Phaf, 2007). The positive and negative emotion-appropriate clips (2 min per clip) were excerpted from comedy and tragic movies respectively. Before and immediately after watching the videos, participants rated the valence and arousal levels of their emotional states by completing the Self-Assessment Manikin (SAM) (Bradley & Lang, 1994), in which they selected one of nine ratings (valence: 1 = very unpleasant, 9 = very pleasant; arousal: 1 = not exciting at all, 9 = very exciting) illustrated by five cartoon figures and the points between any two figures.

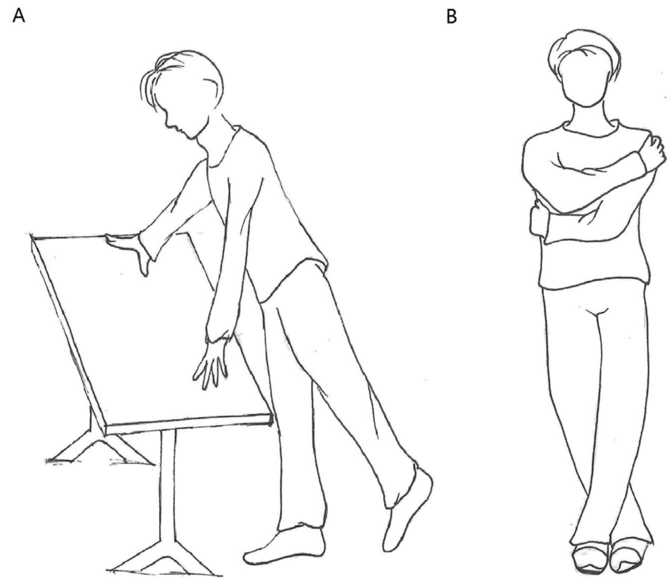

Fig. 1. Illustrations of the open and the closed body postures (panel A and B).

2.5. Post-experimental tests

Immediately after participants completed the experiment, their enjoyment of the experimental task was measured by the question "How did you like the experimental task?" on a scale from 1 (not in the least) to 9 (very much), as in previous studies (Friedman & Förster, 2000, 2002). Participants' feeling of power was measured by the question "How much power did you feel" on a scale from 1 (not at all) to 9 (very much). Participants' effortfulness in maintaining the given body posture was measured by the question "How effortful was it to maintain the open/closed body posture?" on a scale from 1 (not at all effortful) to 9 (very effortful).

2.6. Assessments of performance on AUT problems

Participants' performance on the AUT problem was measured by the scores of fluency and originality (Guilford, 1967; Runco, 1991). Fluency scores were based on the total number of ideas given in the AUT problem. Originality scores were based on statistically infrequent responses. To this end, the ideas that all participants generated for the AUT problem were collected into a comprehensive lexicon. Synonyms were identified and ideas collapsed accordingly. If a response was statistically infrequent (i.e., if 5% or fewer participants in the sample gave the response), then it was given a score of "1". All other responses received scores of "0", regardless of how often they appeared. Following this scoring procedure, two trained raters independently assessed the originality of the two AUT problems for every participant. The inter-rater agreement (ICCs = 0.95) was satisfactory. The internal consistency of the fluency in solving these two problems was satisfactory (Cronbach's alpha coefficient = 0.79), so was that of the originality (Cronbach's alpha coefficient = 0.83). Finally, the fluency and originality scores in solving two problems were averaged for every participant.

Table 1
Levels of valence and arousal of emotional states in pre- and post-induction time points under two conditions in Study 1 ($M \pm SD$).

	Positive condition[a]		Negative condition[b]	
	Pre	Post	Pre	Post
Valence	4.21 ± 0.68	6.42 ± 1.55	4.37 ± 0.68	1.61 ± 0.91
Arousal	3.74 ± 1.79	6.75 ± 1.35	3.46 ± 1.77	6.38 ± 1.9

[a] $N = 77$.
[b] $N = 72$.

2.7. Results

2.7.1. Manipulation check for clarity

It was necessary to check whether watching emotion-appropriate videos did induce the corresponding emotions. A repeated measures ANOVA with Time Point (TIME: pre- vs. post-induction) as a within-subject factor and Emotion Induction (INDUCTION: positive vs. negative) as a between-subject factor was performed on the valence level. There was a significant interaction effect of TIME × INDUCTION, F (1, 147) = 528.81, $p < 0.001$, $\eta_p^2 = 0.78$ (see Table 1). In the pre-induction time point, the valence level showed no difference between two induction conditions, t (147) = 1.51, $p = 0.14$; while in the post-induction time point, the valence level was significantly higher in the positive than in the negative induction condition, t (147) = 22.85, $p < 0.001$, Cohen's $d = 3.78$. Moreover, the valence level increased from the first to the second time point in the positive condition, t (76) = 11.92, $p < 0.001$, Cohen's $d = 1.85$, but decreased in the negative condition, t (71) = 26.65, $p < 0.001$, Cohen's $d = 3.44$. These results indicated that watching emotion-appropriate videos did actually induce positive and negative emotions.

Another repeated measures ANOVA on the arousal level revealed a significant effect of TIME, F (1, 147) = 631.6, $p < 0.001$, $\eta_p^2 = 0.81$ (see Table 1). Overall, the arousal level was higher in the post- than in the pre-induction time point. However, there was neither the main effect of INDUCTION nor the interaction effect of TIME × INDUCTION. These results indicated that participants' arousal level increased after watching videos, but showed no difference between positive and negative induction conditions.

2.7.2. Interaction effect of body posture and emotion on AUT performance

A two-way MANOVA with POSTURE (open vs. closed) and EMOTION (positive vs. negative) as between-subject factors was performed on AUT originality and fluency. *Box's M* = 35.51, $p < 0.001$. POSTURE or EMOTION did not exert main effect on AUT performance. But, there was a significant interaction effect of these two factors on AUT fluency and originality, F (2, 144) = 8.87, $p < 0.001$, $\eta_p^2 = 0.11$.

Specifically, there was a significant interaction effect of POSTURE × EMOTION on AUT fluency, F (1, 147) = 6.22, $p < 0.01$, $\eta_p^2 = 0.04$. In the open posture, the fluency scores ($M = 8.72$, $SD = 5.31$) with positive emotion were significantly higher than those ($M = 6.17$, $SD = 3.37$) with negative emotion (post hoc LSD test, $p < 0.01$); yet no difference was observed between positive and negative emotions in the closed posture (see Fig. 2A). Also, there was a significant POSTURE × EMOTION interaction on AUT originality, F (1, 149) = 16.22, $p < 0.001$, $\eta_p^2 = 0.10$. In the open posture, participants produced ideas with higher originality with positive emotion ($M = 2.85$, $SD = 2.51$) than with negative emotion ($M = 1.33$, $SD = 1.33$) ($p < 0.001$). By contrast, in the closed posture, participants generated ideas with lower originality with positive emotion ($M = 1.43$, $SD = 1.18$) than with negative emotion ($M = 2.32$, $SD = 1.87$) ($p < 0.05$) (see Fig. 2B).

2.7.3. Effects of emotional valence and arousal on AUT performance

Linear regressions were conducted with the post-induction valence and arousal levels as predictors and task performance as the dependent variable. In the open posture, the valence positively predicted AUT fluency ($R^2_{adj} = 0.16$, $F = 7.88$, $p < 0.001$; $\beta = 0.42$, $p < 0.001$) and AUT originality ($R^2_{adj} = 0.25$, $F = 12.44$, $p < 0.001$; $\beta = 0.50$, $p < 0.001$). In the closed posture, the valence ($\beta = -0.23$, $p < 0.05$) and arousal ($\beta = -0.24$, $p < 0.05$) negatively predicted AUT originality ($R^2_{adj} = 0.08$, $F = 4.21$, $p < 0.05$), but they were not significant predictors for AUT fluency ($R^2_{adj} = 0.02$, $F = 1.84$, $p = 0.17$).

2.7.4. Effortfulness, feeling of power, enjoyment for the experimental task and AUT performance

A MANOVA with experimental condition as the between-subject factor was performed on self-rated effortfulness, feeling of power, and enjoyment for the experimental task. *Box's M* = 29.87, $p > 0.05$. There was no effect of experimental condition on these three variables, F (9, 435) = 0.78, $p > 0.05$, $\eta_p^2 = 0.02$.

After these three variables entered into the MANOVA model as covariates, there was still a significant interaction effect of POSTURE × EMOTION on AUT fluency and originality, F (2, 141) = 8.64, $p < 0.001$, $\eta_p^2 = 0.11$.

Enjoyment for the experimental task was positively correlated with AUT fluency and feeling of power ($ps < 0.001$). AUT fluency showed a positive correlation with AUT originality ($p < 0.001$). There was no correlation between other factors (see Table 2).

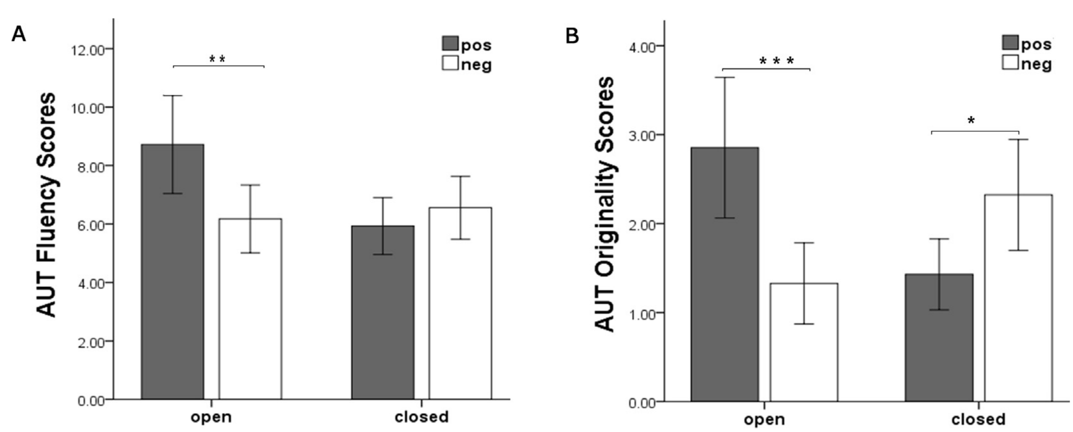

Fig. 2. Alternative Uses Task (AUT) fluency (panel A) and originality (panel B) with positive and negative emotions in the open and the closed body postures (Study 1, $N = 149$). Error bars indicate standard errors of the mean. "pos" mean positive emotion, "neg" means negative emotion. *$p < 0.05$, **$p < 0.01$, ***$p < 0.01$.

Table 2
Descriptive statistics and correlations between effortfulness, feeling of power, enjoyment for the experimental task, AUT fluency and originality (Study 1, $N = 149$).

	M	*SD*	2	3	4	5
1. Effortfulness	4.09	1.05	−0.05	−0.27	0.62	0.48
2. Feeling of power	5.15	1.93		0.31***	0.15	0.96
3. Enjoyment for task	5.47	1.70			0.25***	0.12
4. AUT fluency	6.91	4.00				0.81***
5. AUT originality	2.02	1.92				

*** $p < 0.001$.

3. Study 2

In Study 1, we found that AUT originality was higher in the posture-emotion compatible conditions than in the incompatible conditions. In Study 2, we aimed to (1) replicate the findings in the realistic creative-demanding task besides AUT, (2) test the compatibility effect in a longer period of task performance (i.e., 5 min), and (3) explore the cognitive mechanism underlying the compatibility effect. Based on the *dual pathway to creativity model* (De Dreu et al., 2008), we proposed that the open-positive and closed-negative conditions benefit creativity through the flexibility and the persistence pathways respectively. To test this hypothesis, participants' associative flexibility was measured by the association-chain task (Benedek, Könen, & Neubauer, 2012). We predicted that participants would exhibit the highest flexibility in the open-positive condition. Furthermore, the time duration till participants stop conducting the experimental task may serve as one measure of their processing effort involved in the task (Martin et al., 1993). This time duration was referred as time-on-task, indicating participants' persistence in performing the target task (De Dreu et al., 2008; De Dreu, Nijstad, Baas, Wolsink, & Roskes, 2012). Similarly, we recorded the time duration till participants provided the last idea when they solved a DT problem, which may reflect participants' persistence in solving the problem. We predicted that the time duration would be longest in the closed-negative condition.

3.1. Participants

One hundred and thirty college students (45 males, 85 females; age ranged from 19 to 26 years old, $M = 22.06$, $SD = 1.68$) were recruited in this study. None of them participated in Study 1. The experimental design was the same as in Study 1. Participants were randomly assigned into the open-positive, open-negative, closed-positive, and closed-negative conditions, in which there were 30, 33, 34 and 33 participants respectively. Participants gave written informed consent prior to the experiment, and received approximately 3 US dollar for their participation after the experiment. The protocol of the experiment was approved by the Institutional Ethics Committee at East China Normal University.

3.2. Experimental task

Besides the AUT, the Realistic Presented Problem (RPP; Okuda, Runco, & Berger, 1991; Runco, 2013) was adopted in Study 2. It requires respondents to produce as many solutions as possible to the problems which may occur at school and work. The "flat tire" problem was used in this study: "You are about to ride your bike to school, as you always do, and today you are meeting a friend to plan a school project. But you have a flat tire! You only have about 10 minutes of leeway. You might be able to fix the flat tire in that time, but first you consider alternatives. What ways could you get the bike to work or get to school on time for the important meeting?" The RPP is a typical open-ended test of divergent thinking and creativity potential.

The association-chain task (Benedek et al., 2012) was used to assess associative flexibility. It requires participants to generate long and diversified chains of associations. That is, only the first association should relate to the presented concept, whereas all following associations had to relate to the respectively last associative response (e.g., summer: "beach, sand, castle, knight, horse, race…"). The number of discriminable concepts included in the generated word association chains was conceived to index spontaneous associative flexibility.

3.3. Experimental procedure

Participants were asked to watch videos in order to induce corresponding emotions. Afterwards, they performed the open or closed posture, and then solved one AUT (i.e., "water bottle") and one RPP (i.e., "flat tire") in 10 min (5 min per problem), with a 15 s break between the two problems. We recorded the time duration till participants provided the last idea (solution) when solving the AUT and RPP problems respectively. The sequences of AUT and RPP were balanced for all participants. After a 60 s break, participants solved five association-chain problems (1 min per problem). Participants' oral responses were recorded by a voice recorder and transcribed afterwards for further analysis.

3.4. Emotion inductions

The procedure of emotion inductions was the same as in Study 1.

3.5. Post-experimental tests

As in Study I, enjoyments of AUT and RPP, feeling of power and effortfulness in maintaining the given body posture were measured respectively.

3.6. Assessments of task performance

AUT performance was measured by fluency and originality. The scoring procedure of AUT originality was exactly the same as in Study 1. The inter-rater agreement was satisfactory (two raters, ICC = 0.94). RPP performance was also measured by fluency based on the number of responses and originality based on statistically infrequent responses. However, the scoring standard of originality was slightly different from that in AUT. Given that there was a small number of potential solutions to the "flat tire" problem and a large sample of participants, the responses provided by 5% or fewer participants were really rare. Thus we modified the scoring standard. That is, responses generated by ≤5%, 6–10%, 11–15%, or >15% participants in the sample received 3, 2, 1, and 0 point respectively. Two trained raters independently assessed the RPP originality based on the standard above. The inter-rater agreement was satisfactory (ICC = 0.99). Performance on the association-chain task was measured on the number of discriminable concepts (see Benedek et al., 2012). Scores on five association-chain problems were averaged for every participant.

3.7. Results

3.7.1. Manipulation check for clarity

A repeated measures ANOVA revealed a significant interaction effect of TIME × INDUCTION on valence level, $F(1, 128) = 170.05$, $p < 0.001$, $\eta_p^2 = 0.57$ (see Table 3). In the pre-induction time point, the valence

Table 3
Levels of valence and arousal of emotional states in pre- and post-induction time points under two conditions in Study 2 ($M \pm SD$).

	Positive condition[a]		Negative condition[b]	
	Pre	Post	Pre	Post
Valence	5.48 ± 1.66	6.80 ± 1.79	5.97 ± 1.84	2.85 ± 1.68
Arousal	3.93 ± 1.64	5.66 ± 2.03	4.26 ± 1.87	5.86 ± 2.04

[a] $N = 64$.
[b] $N = 66$.

level showed no difference between two conditions, t (128) $= 1.58$, $p = 0.12$; while in the post-induction time point, the valence level in the positive induction condition was significantly higher than that in the negative condition, t (128) $= 12.98$, $p < 0.001$, Cohen's $d = 2.28$. Furthermore, the valence level increased from the first to the second time point in the positive condition, t (63) $= 6.15$, $p < 0.001$, Cohen's $d = 0.76$, but decreased in the negative condition, t (65) $= 11.86$, $p < 0.001$, Cohen's $d = 1.77$. These results indicated that watching emotion-appropriate videos did induce positive and negative emotions.

There was a significant main effect of TIME on arousal level, F (1, 128) $= 85.66$, $p < 0.001$, $\eta_p^2 = 0.40$. The arousal level was higher in the post- than in the pre-induction time point. That is, participants' emotional arousal increased after watching videos.

3.7.2. Interaction effect of body posture and emotion on AUT performance

A MANOVA with POSTURE and EMOTION as between-subject factors was performed on AUT originality and fluency. *Box's M* $= 21.57$, $p < 0.05$. As in Study 1, there was no main effect of POSTURE or EMOTION, but a significant interaction effect of POSTURE × EMOTION on AUT originality and fluency, F (2, 125) $= 5.74$, $p < 0.01$, $\eta_p^2 = 0.08$.

Specifically, there was a significant interaction effect of POSTURE × EMOTION on AUT fluency, F (1, 126) $= 11.57$, $p < 0.01$, $\eta_p^2 = 0.08$. In the open posture, the fluency scores ($M = 17.97$, $SD = 7.28$) in positive emotion were significantly higher than those ($M = 13$, $SD = 6.11$) in negative emotion (post hoc LSD test, $p < 0.01$), but no difference was observed between two emotional conditions in the closed posture (see Fig. 3A).

There was also a significant interaction effect of POSTURE × EMOTION on AUT originality, F (1, 126) $= 7.59$, $p < 0.01$, $\eta_p^2 = 0.01$. In the open posture, participants produced ideas with higher originality scores in positive emotion ($M = 5.28$, $SD = 3.21$) than in negative emotion ($M = 3.64$, $SD = 2.70$) ($p < 0.05$); while in the closed posture, the originality scores ($M = 4.13$, $SD = 3.12$) in positive emotion were marginally significantly lower than those ($M = 5.62$, $SD = 3.92$) in negative emotion ($p = 0.062$) (see Fig. 3B).

3.7.3. Interaction effect of body posture and emotion on RPP performance

Another MANOVA with POSTURE and EMOTION with between-subject factors were conducted on RPP fluency or originality. *Box's M* $= 37.58$, $p < 0.001$. There was no main effect of POSTURE or EMOTION, but an interaction effect of POSTURE × EMOTION on RPP fluency and originality, F (2, 125) $= 4.54$, $p < 0.05$, $\eta_p^2 = 0.07$.

Specifically, there was an interaction effect of POSTURE × EMOTION on RPP fluency, F (1, 126) $= 7.00$, $p < 0.01$, $\eta_p^2 = 0.05$. In the open posture, the fluency scores ($M = 10.3$, $SD = 3.93$) in positive emotion were significantly higher than those ($M = 7.58$, $SD = 3.78$) in negative emotion ($p < 0.05$); but in the closed posture, the fluency scores showed no difference between two emotional conditions (see Fig. 4A).

There was also an interaction effect of POSTURE × EMOTION on RPP originality, F (1, 126) $= 8.66$, $p < 0.01$, $\eta_p^2 = 0.06$. In the open posture, participants produced higher original ideas in positive emotion ($M = 7.6$, $SD = 8.05$) than in negative emotion ($M = 3.98$, $SD = 4.48$) ($p < 0.05$); but in the closed posture, participants produced lower original ideas in positive emotion ($M = 5.47$, $SD = 4.46$) than in negative emotion ($M = 8.74$, $SD = 8.69$) ($p < 0.05$) (see Fig. 4B).

3.7.4. Persistence in solving AUT and RPP problems in four experimental conditions

Time duration till participants provided the last idea for AUT problems showed differences among four conditions, F (1, 126) $= 5.92$, $p < 0.001$, $\eta_p^2 = 0.12$. Time duration (*sec*) in the closed-negative condition ($M = 285$, $SD = 26.46$) was significantly longer than that in the open-negative condition ($M = 245.45$, $SD = 55.39$) (Post hoc LSD test, $p < 0.01$), but showed no difference with that in the open-positive condition ($M = 276.83$, $SD = 34.43$) and in the closed-positive condition ($M = 270.44$, $SD = 38.27$). Likewise, time duration in solving RPP problem showed significant differences among four conditions, F (1, 126) $= 6.01$, $p < 0.001$, $\eta_p^2 = 0.13$. Post hoc LSD tests revealed that time duration in the closed-negative condition ($M = 269.55$, $SD = 47.09$) was significantly longer than that in the open-negative condition ($M = 213.64$, $SD = 65.95$), the open-positive condition ($M = 239.50$, $SD = 44.8$) and the closed-positive condition ($M = 223.97$, $SD = 65.83$), $p < 0.001$, $p < 0.01$, $p < 0.05$, respectively.

3.7.5. Associative flexibility in four experimental conditions

Performance on the association-chain task showed significant differences among four conditions, F (1, 126) $= 4.91$, $p < 0.01$, $\eta_p^2 = 0.11$. Participants exhibited the highest associative flexibility in the open-positive condition ($M = 19.79$, $SD = 5.93$) than in any other three conditions (open-negative: $M = 14.99$, $SD = 4.74$, $p < 0.001$; closed-positive: $M = 16.69$, $SD = 5.14$, $p < 0.05$; closed-negative: $M = 16.07$, $SD = 4.88$, $p < 0.01$).

3.7.6. Effects of emotional valence and arousal on AUT and RPP performance

Linear regressions were conducted with the post-induction valence and arousal levels as predictors and task performance as the dependent variable. The results revealed similar findings as in Study 1. In the open posture, the valence level positively predicted AUT fluency ($R^2_{adj} = 0.07$, $F = 3.2$, $p < 0.05$; $\beta = 0.29$, $p < 0.05$), AUT originality ($R^2_{adj} = 0.11$, $F = 4.8$, $p < 0.05$; $\beta = 0.34$, $p < 0.01$), RPP fluency ($R^2_{adj} = 0.07$, $F = 3.19$, $p < 0.05$; $\beta = 0.28$, $p < 0.05$), and RPP originality ($R^2_{adj} = 0.06$, $F = 2.92$, $p = 0.06$; $\beta = 0.30$, $p < 0.05$). In the closed posture, the valence

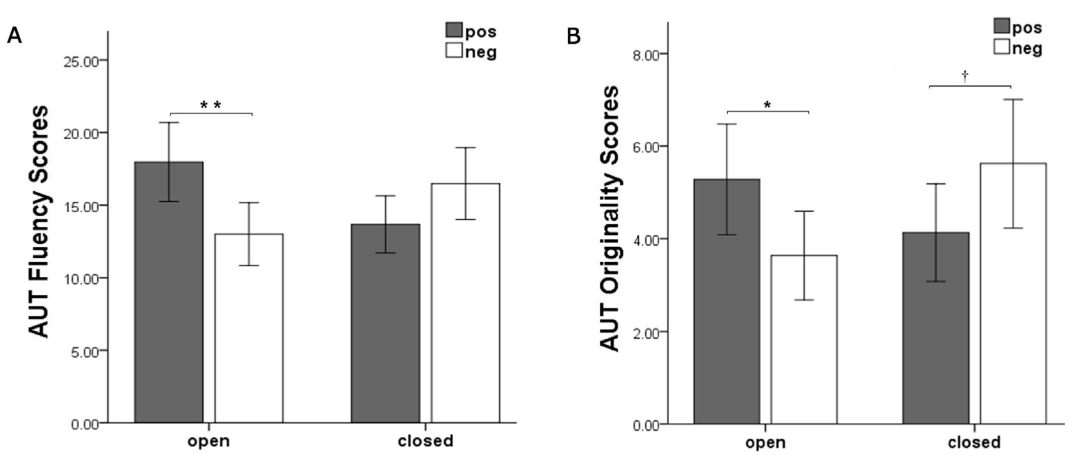

Fig. 3. Alternative Uses Task (AUT) fluency (panel A) and originality (panel B) with positive and negative emotions in the open and the closed body postures (Study 2, $N = 130$). Error bars indicate standard errors of the mean. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{\dagger}0.05 < p < 0.1$.

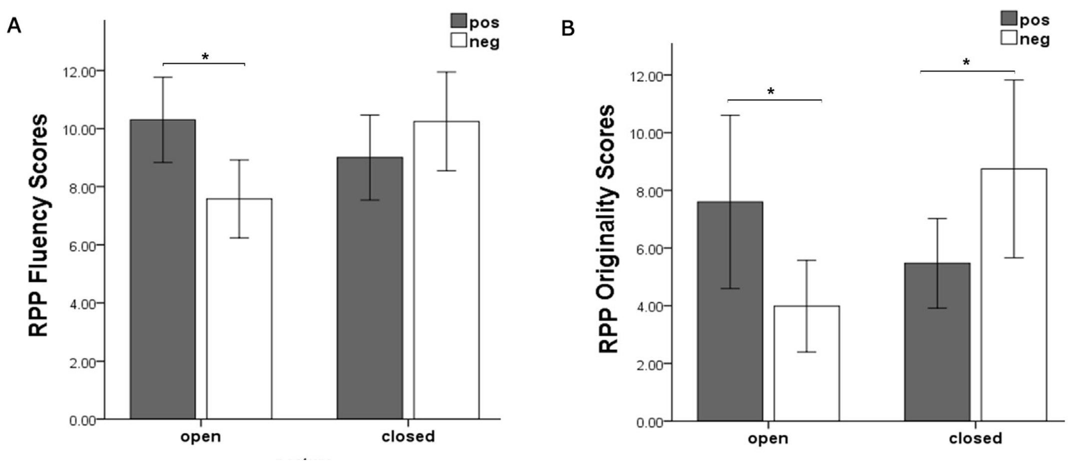

Fig. 4. Realistic Situation Problem (RPP) fluency (panel A) and originality (panel B) with positive and negative emotions in the open and the closed body postures (Study 2, $N = 130$). Error bars indicate standard errors of the mean. $^{*}p < 0.05$,

level negatively predicted AUT fluency ($R^2_{adj} = 0.11$, $F = 3.87$, $p < 0.05$; $\beta = -0.33$, $p < 0.01$), and marginally negatively predicted AUT originality ($R^2_{adj} = 0.07$, $F = 2.55$, $p = 0.08$; $\beta = -0.27$, $p < 0.05$), RPP fluency ($R^2_{adj} = 0.08$, $F = 2.95$, $p = 0.06$; $\beta = -0.24$, $p < 0.05$) and RPP originality ($R^2_{adj} = 0.08$, $F = 2.63$, $p = 0.08$; $\beta = -0.25$, $p < 0.05$).

3.7.7. *Effortfulness, feeling of power, enjoyment for experimental tasks, AUT and RPP performance*

A MANOVA with experimental condition as the between-subject factor was performed on effortfulness, feeling of power, and enjoyment for the experimental tasks. *Box's M* = 11.34, $p > 0.05$. There was no effect of experimental condition on these three variables, $F(9, 378) = 0.79$, $p > 0.05$, $\eta_p^2 = 0.01$.

After these three variables entered into the MANOVA model as covariates, there was still a significant interaction effect of POSTURE × EMOTION on AUT fluency and originality, $F(2, 122) = 4.27$, $p < 0.05$, $\eta_p^2 = 0.07$, as well on RPP fluency and originality, $F(2, 122) = 4.54$, $p < 0.05$, $\eta_p^2 = 0.07$.

Correlation analyses showed that enjoyment for AUT was positively correlated with AUT fluency ($p < 0.01$) and associative flexibility ($p < 0.01$). There were significant positive correlations between any of two variables among AUT fluency, AUT originality, RPP fluency, RPP originality, and associative flexibility (*ps* < 0.01) (see Table 4).

4. Discussion

In this study, we tested whether compatibility or incompatibility between body posture and emotion was beneficial for creativity. In Study 1, we asked participants to solve AUT problems in positive or negative emotional state when performing the open or closed body posture respectively. The results revealed a compatibility effect that AUT originality was higher in the compatible conditions than in the incompatible conditions. In Study 2, we successfully replicated the compatibility effect in both the AUT and the RPP. Also, we confirmed this effect in a longer period of time performance. Thus, the current study discovered that compatibility of body posture and emotion benefits creative performance.

Overall, creative performance showed no difference in the positive and negative emotion conditions. This finding was in line with the *dual pathway to creativity model* (De Dreu et al., 2008), which assumes that both positive and negative emotions could exert positive impacts on creativity through different pathways. Interestingly, one of the novel findings of this study was that people generated ideas (solutions) with higher originality in the posture-emotion compatible conditions. As illustrated in Fig. 1, participants stretched out and took more space in the open body posture, while curled up and took less space in the closed body posture. Open and closed body postures might elicit implicit positive and negative emotions (Briñol et al., 2009; Carney et al., 2010). Consequently, when the open posture met positive emotion or the closed posture met negative emotion, the compatibility of implicit emotions (elicited by body postures) and explicit emotions (induced by watching videos) might enhance the effects of emotions on creativity, therefore promoting creativity. In contrast, in the other two conditions (i.e., positive-closed and negative-open), the implicit and explicit emotions were conflictive; thus, this incompatibility would weaken the effects of emotions on creativity.

Although open-positive and closed-negative conditions both enhanced creativity, we proposed that cognitive mechanism underlying the beneficial effects of these two conditions might be different. Clearly, the open-positive condition induced positive emotions, whereas the

Table 4
Descriptive statistics and correlations between effortfulness, feeling of power, enjoyment for the experimental tasks, AUT and RPP performance (Study 2, $N = 130$).

	M	*SD*	2	3	4	5	6	7	8	9
1. ENJ1	6.18	1.68	−0.09	−0.04	0.21^{**}	0.21^{*}	0.14	−0.04	−0.01	0.19^{*}
2. ENJ2	5.63	1.93		0.04	0.02	0.05	0.06	−0.01	0.02	0.05
3. POW	5.95	1.52			0.02	−0.05	−0.11	−0.05	−0.08	−0.04
4. EFF	5.25	1.34				0.04	0.03	−0.12	−0.02	0.15
5. AUT_F	15.21	6.74					0.82^{**}	0.63^{**}	0.53^{**}	0.46^{**}
6. AUT_O	4.65	3.31						0.52^{**}	0.49^{**}	0.43^{**}
7. RPP_F	9.25	4.30							0.77^{**}	0.42^{**}
8. RPP_O	6.42	6.84								0.39^{**}
9. AF	16.82	5.41								

Note: "ENJ1" and "ENJ2" mean enjoyment for AUT and RPP problems respectively; "POW" means feeling of power; "EFF" means effortfulness; "_F" and "_O" mean fluency and originality respectively; "AF" means the associative flexibility.
* $p < 0.05$.
** $p < 0.01$.

closed-negative condition induced negative emotions. Based on the *dual pathway to creativity model* (De Dreu et al., 2008), it could be predicted that the open-positive and closed-negative promote originality of idea generation through the flexibility and the persistence pathways respectively. In Study 2, we measured participants' associative flexibility by means of the association-chain task (Benedek et al., 2012) and the results showed that participants exhibited the highest associative flexibility in the open-positive condition. This finding indicated that the open-positive condition might facilitate the associative flexibility, thereby promoting creative idea generation. Inspired by the previous studies (De Dreu et al., 2008; De Dreu et al., 2012; Martin et al., 1993), we recorded the time duration till participants provided the last idea (solution) when they solved the creativity problems. This time duration could be conceived as an index of persistence in working on the target problems. As we predicted, participants showed the highest persistence in solving the AUT and RPP problems in the closed-negative condition. This finding indicated that closed-negative condition might help participants think up or dig out highly original ideas, thus benefiting creative idea generation through the persistence pathway.

Participants generated much more ideas (i.e., higher fluency) in the open-positive condition than in the open-negative condition (see Figs. 2A, 3A, 4A). This may be because higher associative flexibility in the open-positive condition facilitated participants to produce plenty of ideas. Notably, the fluency scores in the closed-negative condition were not higher than those in the closed-positive condition. We suggested that participants could think up or dig out highly original ideas through the persistence pathway in the negative-closed condition, but they did not necessarily generate plenty of ideas.

The linear regressions revealed that the valence level of emotion was a positive predictor for the originality scores in the open body posture, but a negative predictor in the closed body posture. That is, the more positive the emotions in the open posture were, or the more negative the emotions in the closed posture were, the higher originality of idea generation would be. These findings provided further evidence to support the compatibility effect between body posture and emotion in creative thinking. In Study 1, the arousal level of emotion was found to be a negative predictor for the originality scores in the closed body posture. The closed body posture might elicit a prevention focus. High arousal in the prevention-focused states would be associated with local processing and a narrowed focus of attention, thereby impeding creative performance (Baas, De Dreu, & Nijstad, 2008; Baas, De Dreu, & Nijstad, 2011; Friedman & Förster, 2008). Accordingly, the higher arousal in the closed body posture were, the lower originality of idea generation would be. However, our study did not investigate the prevention or promotion focuses directly, and the finding was not replicated in Study 2, thus further research is necessary.

Enjoyment for the experimental task was found to be a positive predictor for AUT fluency (see Tables 2 and 4). This result corroborated previous findings that enjoyment for the target task enhanced creative performance (Abele-Brehm, 1992; Hao et al., 2014; Zenasni & Lubart, 2011). The interaction effects of body posture and emotion on AUT and RPP performance were not confounded by the effects of enjoyment for the experimental task, feeling of power and effortfulness of maintaining body posture. The results suggested that these three factors did not supersede or mediate the positive effects of compatibility between body posture and emotion on creative idea generation.

There were three limitations of this study. First, only verbal DT tasks (i.e., AUT and RPP) were employed in this research. Further research should adopt figural DT tasks (e.g., Picture Construction) (Torrance, 1966) and CT tasks (e.g., the Remote Associates Test, RAT) (Mednick, 1962) to test the generality of the compatibility effect. Second, besides open and closed body postures, there are many other body motor actions that could serve as implicit emotional cues (e.g., arm flexion and arm extension). Further research should also assess the reliability of the compatibility effect in the contexts of various body motor actions. Third, the emotions induced by videos had limited generalizability. The emotions induced by real-life events may have more enduring effects and distinct from those induced by video. Further research could adopt various ways (e.g., olfactory stimuli, music, imagination, computer game, casual game, etc.) to induce emotions.

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