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Interactive effect of motivational motor action and emotion on divergent thinking

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ABSTRACT

The present study aimed to investigate the integrated effect of approach/avoidance motor action and emotion on divergent thinking. A total of 115 participants were randomly assigned to one of the four experimental conditions (i.e., approach-positive, approach-negative, avoidance-positive and avoidance-negative). Participants' emotion was induced by videos. They were then asked to solve two Alternative Uses Tasks (AUT) while performing motivational motor action (i.e., arm flexion or extension). Results showed that approach motor action (i.e., arm flexion) engendered more ideas than avoidance motor action (i.e., arm extension). More importantly, participants in approach-negative condition performed better on AUT than those in approach-positive condition. In the same vein, avoidance-positive condition promoted divergent thinking in contrast to avoidance-negative condition. However, no effect of emotion on AUT performance was observed. Findings in this study indicate that the incongruence of motivational motor action and emotion enhances divergent thinking. The experience of novel contexts resulted from such incongruence may account for the benefits.

1. Introduction

Creativity is generally conceived as the ability to generate novel and useful ideas, insights, or problem solutions (Amabile, 1983; Sternberg & Lubart, 1999). As a key component of creativity, divergent thinking (DT) is a facet of cognition that leads in various directions (Runco & Acar, 2012). It is usually referred to as a thought process used to generate original ideas by exploring diverse possible solutions, which is involved in many creative efforts (Kaufman, Plucker, & Baer, 2008; Runco & Acar, 2012). Therefore, factors influencing DT have received a lot of attention in creativity research. One critical predictor is the type of goals that drives individuals' behaviour. Goals include approaching positive stimuli or avoiding negative stimuli. Approaching positive outcomes (approach motivation) and avoiding negative outcomes (avoidance motivation) can exert various effects on DT (Friedman & Förster, 2000, 2002, 2005; Hao, Yuan, Hu, & Grabner, 2014).

1.1. Approach and avoidance motivation with DT

Approach motivation refers to the behaviour tendency energized by positive stimuli, whereas avoidance motivation refers to the behaviour tendency energized by negative stimuli (Elliot & Covington, 2001). They are crucial to successful adaptation: avoidance motivation facilitates surviving, while approach motivation facilitates thriving.

A large body of studies has shown that approach motivation enhances DT whereas avoidance motivation blocks it (Friedman & Förster, 2000, 2002, 2005; Hao et al., 2014; Mehta & Zhu, 2009). For example, Friedman and Förster (2002) found that arm flexion associated with approach motivation engendered better DT than arm extension associated with avoidance motivation. According to Cacioppo, Priester, and Berntson (1993), over the course of lifetime, individuals repeatedly flexed their arms to acquire desired objects (i.e., approach motivation). On the other hand, individuals repeatedly extended their arms to reject undesired objects (i.e., avoidance motivation). Thus, arm flexion is considered as an approach motor action whereas arm extension as an avoidance motor action (Cacioppo et al., 1993; Friedman & Forster, 2010, 2002). Approaching appetitive objects signals a benign environment, while avoiding aversive objects signals a dangerous environment. As a result, encouraged by a benign environment clue, individuals tend to adopt heuristic strategies that benefit creative thinking. However, individuals who encounter a dangerous situation usually adopt systematic strategies, which are harmful to DT (Friedman & Förster, 2002, 2005; Hao et al., 2014).

Though researchers found approach motivation improved DT in comparison to avoidance motivation, other researchers demonstrated that persistent and systematic thinking style underlying avoidance

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motivation may also facilitate DT. Avoidance-motivated individuals are easier to feel fatigue. However, they would put more effort into the task if they conceived the task as functional for the next task, which promoted DT (Roskes, De Dreu, & Nijstad, 2012). Moreover, Icekson, Roskes, and Moran (2014) have argued that optimism can mediate the undermining effect of avoidance on DT by mitigating negative emotion. Therefore, it is possible that the systematic processing underlying avoidance motivation could bring about better DT when more effort was exerted or negative emotion was attenuated.

1.2. Approach/avoidance motivation, emotion, and DT

Approach/avoidance motivation and emotion are correlated with each other. Emotions involve multiple distinct processes including affect, appraisal of the valence of a stimulus (its goodness or badness), physiological arousal, and some sort of subjective feelings (Ellsworth, 1994). These correlated processes are posited to operate in parallel. The dissociability of these components lends credence to the possibility that some subset of them can be triggered without coactivating the "subjective feeling" component (Friedman & Forster, 2010). Approaching rewards or avoiding noxious objects signals safety or danger, leads to the appraisal of goodness or badness (Cacioppo et al., 1993). Thus, approach/avoidance motor action can be viewed as implicit affective cues by appraising the goodness or badness of the environment (Friedman & Forster, 2010).

In addition, according to Regulatory Focus Theory, both approach-avoidance behaviour and emotional sensitivities are parts of promotion/prevention motivation system (Higgins, 1997). To fully understand the psychological quality of emotions, promotion or prevention focus must be considered (Cacioppo, Gardner, & Berntson, 1999). Specifically, when individuals successfully reach the appetitive ends, they can have positive emotions such as happiness. Failing to reach appetitive ends leads to negative emotions such as sadness. Likewise, successfully avoiding aversive stimuli leads to positive emotions such as ease or calm, whereas failing to avoid aversive stimuli evokes negative emotions such as fear. Taken together, it is interesting to investigate how implicit emotional cues (i.e., approach/avoidance motor action) and explicit emotions shape DT.

Within the emotion-DT literature, most researchers have distinguished emotion in terms of valence and activation/arousal. De Dreu, Baas, and Nijstad (2008) have developed a dual pathway to creativity model to understand emotion's influence on DT. This model accounts for the joint mood activation and mood valence effect on DT. According to the model, activating moods (e.g. angry, fearful, happy, elated moods) facilitate creative performance through enhanced cognitive flexibility when the tone is positive or through enhanced persistence when the tone is negative. That is, mood activation determines the likelihood of DT, while valence determines the routes by which DT comes out (flexibility route or perseverance route). Recently, researchers have distinguished emotions in terms of valence, activation and orientation (Baas, De Dreu, & Nijstad, 2011; Yeh, Lai, & Lin, 2016). Orientation indicates whether the emotional states focus on approaching rewards or avoiding threats. For example, Gasper and Middlewood (2014) have found that respondents in approach-oriented states (elated) performed better on making creative associations than those in avoidance-oriented states (distressed).

1.3. The present study

Taken together, both motivational motor action and emotion share the same attribute of orientation (approach vs. avoidance). Meanwhile, both are predictors of DT. Though arm motor actions associated with approach/avoidance are not capable of inducing explicit emotions (Friedman & Förster, 2000, 2002), they may occur simultaneously with situations inducing emotions such as happiness or fear during creative ideation. However, it is still unknown how these two factors interact during DT.

To investigate this question, participants in this study were asked to watch a 2-minute video to induce positive/negative emotions. Afterwards, they completed the DT task while performing arm flexion (approach motor action) or extension (avoidance motor action). Efforts of executing the arm motor actions and the enjoyment of task were measured to rule out the potential contaminant effects of these variables on DT. We were interested in the question whether the interaction between motivational motor action and emotion could promote DT. We were not able to make exact prediction for the following reasons. On the one hand, motivational motor action combined with emotion may promote DT. That is, approach motor action combined with positive emotion may lead to higher DT than other combinations of motivational motor action and emotion. On the other hand, motivational motor action may interact with emotion during creative thinking. That is, approach motor action with negative emotion, or avoidance motor action with positive emotion could promote DT.

2. Method

2.1. Participants and design

A total of 115 college students participated in the experiment. A 2 (Motivational Motor Action: approach motor action vs. avoidance motor action) × 2 (Emotion: positive emotion vs. negative emotion) between-subject design was employed. Participants were randomly assigned to one of the four experimental conditions. The data of 7 participants were excluded from further analyses, because these participants did not observe the instruction of thinking ideas that are both novel and useful. Based on evaluation of raters, their ideas were not of usefulness at all. Thus, the final sample consisted of 108 participants (85 females, 23 males; age ranged from18 to 28 years old, $M = 22.05$, $SD = 2.56$). There were 26, 28, 26, 28 participants in the approach-negative, approach-positive, avoidance-negative, and avoidance-positive conditions respectively. Results of Pearson Chi-square test showed no difference in gender ratios among four conditions, $\chi^2 = 0.54$, $p = .91$. All participants were right-handed and native speakers of Chinese. They gave written informed consent prior to the experiment and received approximately 5 US dollars for their participation. The protocol of the experiment was approved by the Institutional Ethics Committee at East China Normal University.

2.2. Procedure

Upon arrival, participants were seated at a table approximately 29.5 in. in height. An instruction sheet with a cover story was provided to them, similar as what used in previous studies (Friedman & Förster, 2000, 2002):

> "Today, you will be participating in a study examining the effects of hemispheric lateralization on problem solving. We are trying to understand the relationship between left and right brain activation and the ability to solve certain type of problems. Basically, there is an on-going debate, with some people saying that the left hemisphere is the centre for this type of cognitive activity and others saying that the right hemisphere is more critical."

Following the cover story, participants were asked to watch videos to induce emotions (see details in Emotion inductions). Then, participants were informed that he or she had been randomly assigned to the left hemisphere activation condition. They were required to assume a particular right arm position. The experimenter demonstrated how to perform arm flexion or extension. A computer screen was placed on the table, and two foam balls were fixed on the top and the underside of the table. In arm flexion condition, a participant's right elbow was bent (Friedman & Förster, 2002), with the palm upward holding the ball on the underside of the table (see panel A in Fig. 1). In arm extension

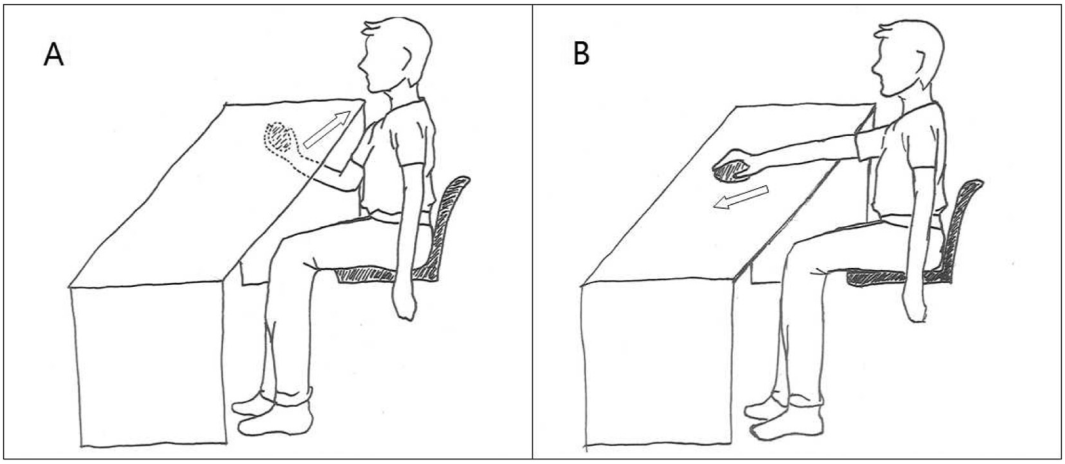

Fig. 1. Illustrations of arm flexion (A) and arm extension (B). Arrow indicates the orientation of arm to the palm ball.

condition, the right elbow was stretched forward with the palm lightly downward holding the ball on the top of the table (see panel B in Fig. 1).

While flexing or extending arms, participants were asked to solve two AUT problems (i.e., a brick and chopsticks) in 10 min (5 min/problem), with a 1-min break between the two problems. They were encouraged to try their best to produce ideas that would be thought of by no one else, as suggested by Harrington (1975).

2.3. Emotion inductions

As in previous studies, 2-minute videos were used to induce emotions (Forgas & East, 2008; Hao, Xue, Yuan, Wang, & Runco, 2017). The positive and negative emotion-appropriate video clips were excerpted from comedy and horrible movies respectively. Prior to and immediately after the induction, participants' self-rated emotional states were measured by means of the Self-Assessment Manikin separately (Bradley & Lang, 1994), ranging from 1 to 9 (valence: 1 = *very unpleasant*, 9 = *very pleasant*; arousal: 1 = *not exciting at all*, 9 = *very exciting*).

2.4. Materials and measures

2.4.1. Experimental task

The AUT was used as the experimental task. It requires respondents to generate as many unusual or original uses as possible for common objects. It is a well-established test of creative potential (Guilford, 1967; Runco & Mraz, 1992). Performance on this task has been demonstrated to be a reliable predictor of actual, real-world creative performance (Runco & Acar, 2012).

2.4.2. Assessment of AUT performance

DT performance was evaluated in terms of fluency, originality and flexibility (Guilford, 1967; Runco & Pritzker, 1999). First, *fluency* was determined by counting the number of non-redundant ideas generated by each participant. Secondly, *originality* was determined by statistically infrequence of responses. To assess it, all ideas were collected into a comprehensive lexicon. Synonyms were identified and ideas collapsed accordingly. The responses scored "1" if they were statistically infrequent (i.e., if 5% or fewer participants in the sample gave the response). All other responses scored "0". Following this scoring procedure, two trained raters independently assessed the originality of all ideas for each participant. The inter-rater agreement was satisfactory (Cronbach's alpha coefficient = 0.79). Finally, two trained raters rated *flexibility* of each idea. *Flexibility* was defined as the categories all ideas belonged to. The raters independently categorized all ideas into 7 to 10 categories. The internal consistence of the two raters was satisfactory (Cronbach's alpha coefficient = 0.74). The fluency, originality and flexibility ratings from two raters were averaged into a single score for each participant.

2.4.3. Post-experiment tests

After completing the experiment, participants' effortfulness of maintaining the arm motor actions was measured by asking them "how effortful was it to maintain the arm flexion or extension?" on a scale ranging from 1 (*not at all effortful*) to 9 (*very effortful*). In addition, their enjoyment of AUT was measured by asking: "How do you like to solve AUT in this experiment?" on a scale ranging from 1 (*not at all*) to 9 (*very much*).

3. Results

3.1. Manipulation checks of emotion induction

Two-way ANOVAs with Emotion (negative vs. positive) and Induction (pre-inducing vs. post-inducing) as between-subject factors were performed on the valence and arousal level of emotion separately.

Results showed significant main effects of Emotion and Induction on valence, F (1, 106) = 6.04, $p < .05$, $\eta_p^2 = 0.05$; F (1, 106) = 84.48, $p < .001$, $\eta_p^2 = 0.44$. In addition, the interaction effect of Emotion × Induction was significant, F (1, 106) = 22.51, $p < .001$, $\eta_p^2 = 0.18$. Specifically, as shown in Table 1, participants with negative emotion felt less delightful after watching the video than that before watching it, t (51) = −6.36, $p < .001$, Cohen's d = −1.78. In contrast, participants with positive emotion showed more delightfulness than that before the induction, t (55) = 3.83, $p < .001$, Cohen's d = 1.03.

Results also revealed significant main effects of Emotion and Induction on the arousal, F (1, 106) = 18.40, $p < .001$, $\eta_p^2 = 0.13$; F (1, 106) = 5.32, $p < .001$, $\eta_p^2 = 0.13$. Moreover, significant interaction effect between Emotion × Induction was found, F (1, 106) = 55.24, $p < .001$, $\eta_p^2 = 0.34$. Specifically, as displayed in

Table 1
Emotional valence and arousal before and after induction.

	Emotion	Pre	Post	t	Cohen's d
Valence	Positive	5.48 ± 1.44	6.13 ± 1.54	3.83***	1.03
	Negative	5.67 ± 1.76	3.58 ± 2.09	−6.36***	−1.78
Arousal	Positive	4.94 ± 1.83	5.73 ± 1.70	3.58**	0.97
	Negative	4.76 ± 1.53	7.23 ± 1.57	8.42**	2.36

** $p < .01$.
*** $p < .001$.

Table 1, the arousal of participants with negative emotion was higher after induction than that before induction, t (51) = 8.42, $p < .01$, Cohen's $d = 2.36$. Similarly, participants with positive emotion showed higher arousal after induction than that before induction, t (55) = 3.58, $p < .01$, Cohen's $d = 0.97$.

3.2. Motivational motor action and emotion's effect on divergent thinking

Three two-way ANOVAs, with Action (arm flexion vs. arm extension) and Emotion (positive vs. negative) as between-subject factors, were conducted on the fluency, originality and flexibility scores, respectively.

With respect to fluency, results revealed a significant main effect of Action, F (1, 104) = 4.83, $p < .05$, $\eta_p^2 = 0.04$. Participants with arm flexion generated more ideas ($M = 8.47$, $SD = 4.30$) than those with arm extension ($M = 7.08$, $SD = 2.82$). Also, a significant interaction effect of Action × Emotion on fluency was observed, F (1, 104) = 11.02, $p < .01$, $\eta_p^2 = 0.10$.

Specifically, in the arm flexion condition, participants with negative emotion ($M = 9.98$, $SD = 4.55$) showed higher fluency than those with positive emotion ($M = 7.70$, $SD = 3.60$), t (52) = 32.62, $p < .05$, Cohen's d = 0.73. However, in the arm extension condition, participants with negative emotion showed lower fluency ($M = 6.29$, $SD = 2.80$) than those with positive emotion ($M = 7.82$, $SD = 2.68$), t (52) = −0.2.01, $p < .05$, Cohen's $d = -0.56$ (see Fig. 2).

For originality, marginally significant main effect of Action was observed, F (1, 104) = 3.12, $p = .08$, $\eta_p^2 = 0.03$. Participants with arm flexion ($M = 3.89$, $SD = 2.91$) showed higher originality than those with arm extension ($M = 3.10$, $SD = 1.97$). In addition, a significant interaction effect of Action × Emotion was found, F (1, 104) = 5.48, $p < .05$, $\eta_p^2 = 0.05$. As shown in Fig. 3, in the arm flexion condition, participants with negative emotion showed higher originality ($M = 4.73$, $SD = 3.35$) than those with positive emotion ($M = 3.11$, $SD = 2.22$), t (52) = 2.12, $p < .05$, Cohen's $d = 0.59$. However, in the arm extension condition, there was no significant difference in originality between participants with negative emotion and those with positive emotion, t (52) = 1.06, $p > .05$ (see Fig. 3).

For flexibility, results showed a significant interaction effect of Action × Emotion, F (1, 104) = 6.88, $p < .05$, $\eta_p^2 = 0.06$. In the arm flexion condition, participants with negative emotion showed higher flexibility ($M = 5.36$, $SD = 1.27$) than those with positive emotion ($M = 4.46$, $SD = 1.45$), t (52) = 2.43, $p < .05$, Cohen's $d = 0.67$. However, in the arm extension condition, there was no difference in flexibility between participants with negative emotion and those with positive emotion, t (52) = 1.32, $p > .05$ (see Fig. 4).

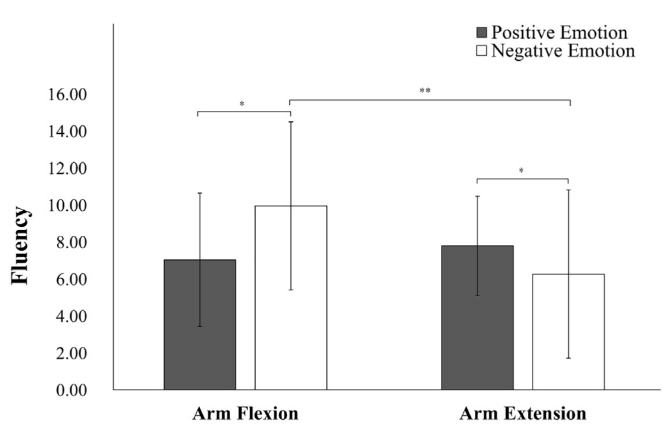

Fig. 2. Alternative Uses Task (AUT) fluency in different conditions. Error bar indicates standard errors of the mean.

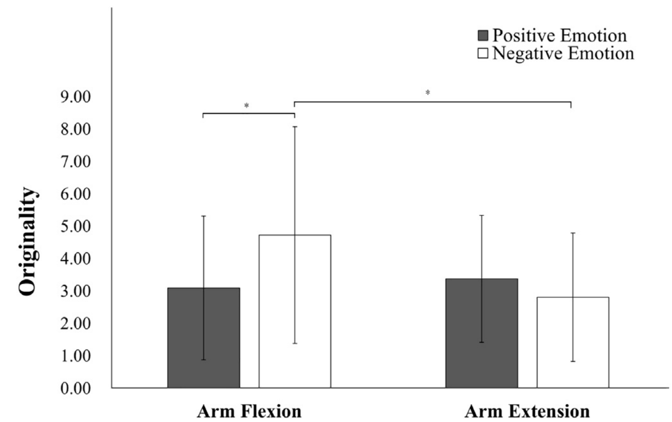

Fig. 3. Alternative Uses Task (AUT) originality in different conditions. Error bar indicates standard errors of the mean.

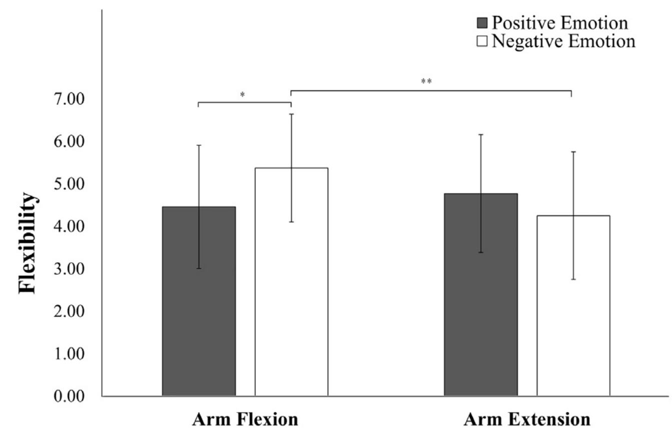

Fig. 4. Alternative Uses Task (AUT) flexibility in different conditions. Error bar indicates standard errors of the mean.

3.3. Effects of motor action effort and task enjoyment on divergent thinking

To examine the possible effect of motor action effort and task enjoyment on divergent thinking, independent t-tests were conducted. Motor action effort and task enjoyment showed no difference between arm flexion and extension, t (106) = 0, $p > .05$; t (106) = 1.90, $p > .05$. In addition, a series of correlation analyses showed that motor action effort was unrelated to originality, fluency and flexibility ($ps > 0.05$). Similarly, results showed no significant correlation between the task enjoyment and originality, fluency and flexibility ($ps > 0.05$).

When effort and task enjoyment were entered into the above ANOVA models as covariates, the main effect of Action on fluency remained significant ($p < .05$, $\eta_p^2 = 0.04$); the main effect of Action on originality remained marginally significant ($p = .08$, $\eta_p^2 = 0.03$); the interaction effects of Action × Emotion on originality ($p < .05$, $\eta_p^2 = 0.05$), fluency ($p < .01$, $\eta_p^2 = 0.10$), and flexibility ($p < .05$, $\eta_p^2 = 0.06$) remained significant.

4. Discussion

The present study investigated the effect of motivational motor action and emotion on DT. In line with our latter prediction, results showed an interaction effect of these two factors on DT. Specifically, arm flexion with negative emotion engendered higher DT in terms of originality, fluency and flexibility. Similarly, arm extension with positive emotion brought about better performance on DT in terms of fluency. Taken together, the findings indicate that the incongruence between motivational motor action and emotion promotes DT.

Participants with approach arm motor action (i.e., arm flexion) exhibited better DT performance in the negative emotion than in the positive emotion. Results demonstrated higher fluency, originality, and flexibility for participants with negative emotion than those with positive emotion during arm flexion (see Figs. 2, 3, and 4). As approach motivation is accompanied with positive stimuli while avoidance motivation with negative stimuli, it is reasonable to identify approach motor action as incongruent with negative emotion, or avoidance motor action incongruent with positive emotion (Yeh et al., 2016). Previous work has found that the incongruence effect can facilitate creative thinking. For example, individuals preferring rational thinking showed better DT when asked to use an intuitive thinking style (i.e., incongruence condition) than use a rational thinking style (i.e., congruency condition) (Dane, Baer, Pratt, & Oldham, 2011). In addition, the incongruence between pre-existing mood and induced emotion facilitates creative performance (Forgeard, 2011). Incongruence places oneself in a novel context, which is beneficial for novel idea generation (Dane et al., 2011). Specifically, people tend to consider the environment as novel and unusual in incongruent context, which promotes the combination of unrelated ideas.

Moreover, avoidance-motivated participants with positive emotion came up with more ideas than those with negative emotions (see Fig. 2). Except for the incongruence effect explanation, researchers have demonstrated that the DT of avoidance-motivated individuals can be enhanced when the hedonic tone of affective reactions was moderated by optimism. Positive emotions evoked by optimism can mitigate negative emotion induced by avoidance motivation, which can broaden individuals' attention scope (Icekson et al., 2014). Instead of optimism's moderation, the present study induced explicit emotion by asking participants to watch videos. We found explicit positive emotion enhanced avoidance-motivated individuals' DT in terms of fluency. Therefore, the induced positive emotion may attenuate the possible negative effect of arm extension on DT. However, the attenuating effect only works on fluency but not on flexibility and originality in the current study. According to the *serial-order effect* of DT-the creative quality of ideas tends to increase over time, earlier ideas generated by participants are not novel (Beaty & Silvia, 2012). It is possible that the attenuating effect of positive emotion on avoid motor action works only at the earlier time during creative thinking process.

Consistent with previous studies, the present study found more ideas were generated during arm flexion than that during arm extension (Friedman & Förster, 2002; Hao et al., 2014). From the perspective of evolutionary psychology, individuals flex their arms to approach tempting stimuli and extend their arms to avoid aversive ones (Cacioppo et al., 1993). Thus, when flexing arms, individuals may perceive the environment as safe. Therefore, they prefer to use the heuristic process strategies to solve problems. Alternatively, with arm extension, individuals may perceive the environment as dangerous. Thus, they prefer to use systematic process strategies to avoid threats. Heuristic processing strategies promote DT, whereas systematic processing strategies undermine DT (Friedman & Förster, 2002).

Of note, positive and negative emotions' influence on DT showed no difference. In this study, happiness was induced as a positive mood and fear as a negative state. Both are similar in activating but different in valence (De Dreu et al., 2008). Activating moods (e.g. fear, happiness) led to higher fluency and originality than deactivating moods (e.g. sadness, depression) (De Dreu et al., 2008). Moreover, prevention-focused mood states that activated the individuals (unfulfilled prevention goals, fear) would lead to similar levels of DT as promotion states (i.e. happiness) (Baas et al., 2011). As happiness and fear in the present study were both activating emotions, they may exert similar effects on DT. Moreover, effort of performing arm motor actions and enjoyment of tasks showed no difference between arm flexion and extension in this study. These findings excluded the possible effects of these two factors on DT.

The study had some limitations. First, we manipulated arm flexion and extension as motivational motor actions, but did not check the association of them. As previous studies have shown the strong association between arm flexion/extension and approach/avoidance, it is rational to conceive it as a solid way to induce approach and avoidance motivation. Second, our findings showed the interaction effect between emotion and motivational motor action on DT. However, the emotion valence and arousal varied in the same direction for positive emotion after induction. Therefore, we must admit that it is impossible to clarify the differential impact of valence and arousal on the interaction between emotion and motivational motor action. The interaction of motivational motor action, valence, and arousal on DT should be further analyzed in future studies. Third, although we checked the valence and arousal of the induced emotion, specific induction of happiness and fear was not checked. Future studies should check the induction of specific emotional state like fear or happiness as well.

Declarations of interest

None.

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