AMERICAN PSYCHOLOGICAL ASSOCIATION

Emotion

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ISSN: 1528-3542

2025, Vol. 25, No. 1, 18–32
https://doi.org/10.1037/emo0001410

Situation Covariation and Goal Adaptiveness? The Promoting Effect of Cognitive Flexibility on Emotion Regulation in Depression

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Cognitive inflexibility as a generalized characteristic of depression has been closely implicated in maladaptive coping with changing situations and goals in daily life. The association between cognitive flexibility and depression can be elucidated by situation covariation and goal adaptiveness of emotion regulation flexibility (ERF), which facilitates adaptive responses to changing environments. However, little is known about the contribution of cognitive flexibility to emotion regulation in depression under changing situations and goals. To address this gap, we performed three experiments to assess situation covariation and goal adaptiveness of ERF, and we further examined the contribution of situation covariation and goal adaptiveness to the association between cognitive inflexibility and depression. The results of Experiments 1 ($N = 120$) and 2 ($N = 117$) showed a significantly negative correlation between cognitive flexibility and goal adaptiveness (but not situation covariation) of ERF. Further mediation analysis revealed the contribution of goal adaptiveness scores to the relationship between cognitive flexibility and depression. In Experiment 3 ($N = 93$), we performed a 14-day training of cognitive flexibility and observed that the training increased goal adaptiveness, but not situation covariation, of ERF and reduced symptoms of depression. Furthermore, the improvement of goal adaptiveness scores significantly mediated the effect of cognitive flexibility on depressive remission. In sum, these findings identified a vital involvement of goal adaptiveness of ERF in the effect of cognitive flexibility on depression.

Keywords: emotion regulation, cognitive flexibility, depression, situation, goal

Supplemental materials: https://doi.org/10.1037/emo0001410.supp

Emotion dysregulation is one of the most salient features of depression, which is associated with deficits in cognitive flexibility (Kircanski et al., 2012; McIntyre et al., 2013; Sloan et al., 2017). Cognitive flexibility refers to an individual's ability to adjust their behavioral responses and strategies when faced with complex information and environment (Cañas et al., 2003). Given that depression has been characterized by persistent negative mood and inflexible responses, cognitive flexibility may act as a protective factor against emotion dysregulation in depression (Braem & Egner, 2018; Kashdan & Rottenberg, 2010). Converging fields of studies indicated that individuals with higher cognitive flexibility are better able to adjust their emotional responses when facing multiple life

This article was published Online First August 29, 2024.
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We reported how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study. The study was preregistered on the Open Science Framework accessible at https://osf.io/3khx9 (Gao, 2022). The data and materials are available in public projects on the Open Science Framework at https://osf.io/498nk (Gao, 2024). The authors have no conflicts of interest to declare with respect to the authorship or the publication of this article.

This scientific work was supported by the Science Fund for Distinguished Young Scholars of Sichuan Province (No. 2023NSFSC1938) awarded to JiaJin Yuan; the National Natural Science Foundation of China Grant 32300873 awarded to Wei Gao and Grants 31671164 and 31971018; and the Humanities and Social Sciences Youth Foundation, Ministry of Education in China Grant 23YJC190008 awarded to Wei Gao. The authors thank Qinghua He from Southwest University for valuable advice contribution to this study.

Wei Gao played a lead role in conceptualization, data curation, formal analysis, investigation, supervision, validation, visualization, writing–original draft, and writing–review and editing and a supporting role in funding acquisition. Xinyu Yan played a supporting role in formal analysis, investigation, methodology, software, supervision, validation, and writing–review and editing. Yongqiang Chen played a supporting role in data curation, formal analysis, investigation, methodology, software, and writing–review and editing. Jiemin Yang played a supporting role in formal analysis, methodology, project administration, supervision, and writing–review and editing. JiaJin Yuan played a lead role in conceptualization, funding acquisition, project administration, validation, and writing–review and editing and a supporting role in formal analysis and methodology.

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stressors and negative situations, thereby reducing their risk of depression (Bonanno & Burton, 2013; Crocker et al., 2013; LeMoult & Gotlib, 2019). Therefore, clarifying the association between cognitive flexibility and emotion regulation (ER) has implications for our understanding of the development and maintenance of depressive symptoms.

Inflexible responses are usually maladaptive because real-life situations and goals are constantly changing. This can be particularly challenging for individuals who struggle with depression (Joormann & Stanton, 2016; Nolen-Hoeksema, 2012). Increasing evidence showed that emotion regulation is influenced by situations and goals beyond the use and effectiveness of emotion regulation strategies alone (Aldao & Tull, 2015; Kashdan & Rottenberg, 2010). For example, researchers found that cognitive reappraisal was inappropriate in highly stressful situations (Silvers et al., 2015; Troy et al., 2013), while expressive suppression, which was considered nonadaptive, can successfully regulate individual negative emotions to adapt to self-goals (Roos et al., 2018; Yuan et al., 2014). Moreover, individuals with higher cognitive flexibility consume fewer resources to complete the task of down-regulating negative emotions (McRae et al., 2012; Zaehringer et al., 2018), while cognitive inflexibility was frequently found in depressed individuals who struggle with variable living situations and goals (Owens & Derakshan, 2013; Wagner et al., 2015). However, until now little is known about the contribution of cognitive flexibility to emotion regulation in depression, especially in coping with changing situations and goals.

In recent years, the theory of emotion regulation flexibility (ERF) proposed two concepts: situation covariation and goal adaptiveness to depict an individual's ability to respond flexibly to changing situations and goals, which can be facilitated by cognitive flexibility (Aldao et al., 2015; Gross & Jazaieri, 2014). situation covariation of ERF refers to the degree of temporal consistency between the variation of emotion regulation strategies and changing situations. Prior studies emphasized it is necessary for individuals to stabilize their emotional state in changing situations by timely adjustment of emotion regulation strategies (stopping, maintaining, or switching), which are considered basic components of cognitive flexibility (Aldao & Tull, 2015). On the other hand, goal adaptiveness of ERF refers to one's capacity to pursue and achieve different goal-driven behaviors during emotion regulation. For example, it is considered goal adaptiveness that a police officer is required to regulate their own emotions while also achieving memory-related goals in crime investigations. Several studies put forward that emotion regulation is a motivated process, which supports goal pursuit. This motivated process is important for personal adaptability in changing situations, as the ability to pursue— and achieve— different goals is an essential aspect of one's ability to interact successfully with the environment (Boudreaux & Ozer, 2013; Millgram et al., 2020). Furthermore, recent studies have shown that lower cognitive flexibility is associated with impaired switch function, while higher cognitive flexibility can increase individuals' subjective well-being by facilitating the achievement of different goals (Thomsen, 2016; Van Bost et al., 2022). Therefore, it is plausible that cognitive flexibility may promote the processes of situation covariation and goal adaptiveness of ERF.

More importantly, cognitive inflexibility is a typical characteristic of depressed individuals when coping with changing situations and goals. Previous studies found that individuals with lower cognitive flexibility often showed depressive rumination, which might be attributed to inflexible regulation processes in changing situations and played potential roles in the development of mood disorders (Gabrys et al., 2018; Joormann & Stanton, 2016; Morris & Mansell, 2018). In addition, several clinical evidence also indicated that the onset of depression is associated with failure to pursue or achieve goals (Jones et al., 2009; Moberly & Watkins, 2010), while flexible goal adjustment is positively correlated to cognitive flexibility and negatively correlated to depression (Dunne, 2012; Wrosch et al., 2013). Therefore, we speculate that there is an effect of cognitive flexibility on depression by promoting situation covariation and goal adaptiveness of ERF.

To test this hypothesis, we first implemented a preliminary experiment to examine the relationship between cognitive flexibility and the use of emotion regulation strategies (e.g., distraction, reappraisal, suppression) to control potential influences of different strategies in the following tasks. Second, we assessed the degree of situation covariation and goal adaptiveness of ERF using two experiments, respectively. Moreover, to determine the contribution of these two processes, we also tested the mediation effects of situation covariation and goal adaptiveness of ERF in the relationship between cognitive flexibility and depression in Experiments 1 and 2, respectively. Finally, we further tried to enhance situation covariation and goal adaptiveness of ERF in subclinical depression using a cognitive flexibility training task in Experiment 3. That is, the present study is designed to clarify the pathways subserving the contribution of cognitive inflexibility to depression in terms of situation covariation and goal adaptiveness.

Preliminary Experiment

Method

Participants and Materials

Before assessing situation covariation and goal adaptiveness of ERF, we first tested the association between cognitive flexibility and emotion regulation strategies. A total of 85 right-handed college participants were recruited for this study (43 females; $M_{age} = 21.64$ years, $SD = 2.65$ years). All participants signed written informed consents and were paid for their participation. This study was approved by the local ethical committee of Southwest University. Emotional materials consisted of negative and neutral images selected from the International Affective Picture System and the Chinese Affective Picture System. All of the presented stimuli were pretested for arousal and valence; negative images ($M = 7.28$, $SE = 0.12$) were significantly more arousing than neutral images ($M = 3.72$, $SE = 0.12$), $d = 3.56$, $t(29) = 20.86$, $p < .001$, 95% confidence interval (CI) [3.21, 3.90]. For valence ratings, negative images ($M = 7.46$, $SE = 0.15$) led to significantly higher scores than neutral images ($M = 4.29$, $SE = 0.09$), $d = 3.16$, $t(29) = 18.02$, $p < .001$, 95% CI [2.81, 3.52]. All images were selected to match for size (15×10 cm^2) and resolution (100 pixels/in.), luminance, and complexity.

Prior to the start of experimental tasks, participants were first administered the Chinese version of the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003). The ERQ was used to evaluate the use of emotion regulation strategies in daily life. This scale has been shown to have good internal consistency and test–retest reliability. Cronbach's αs of ERQ were .82 for the Reappraisal subscale and .67 for the Suppression subscale in this study. Considering the potential influence of individual traits on emotion regulation, we incorporated additional control variables into our study. Specifically, we included the Chinese version of the 48-item Neuroticism questionnaire derived from the Neuroticism–Extraversion–Openness Five-Factor Personality Inventory. This questionnaire assesses individuals' propensity to experience psychological distress (Kurylo & Stevenson, 2011). Furthermore, we administered the State–Trait Anxiety Inventory to capture variations in trait anxiety among participants (Shek, 1988). These measures were included as covariates in subsequent correlation analyses in the preliminary experiment, to ensure more stable findings regarding the relationship between cognitive flexibility and different emotion regulation strategies.

Behavioral Measurements

We adopted a typical cue-viewing task to assess the use of emotion regulation strategies during the task (Goldin et al., 2008). In each trial, participants were first presented with cues ("Look" or "Decrease") for 2 s, and then neutral and negative images were randomly presented to participants for 8 s. Participants were told to react naturally to neutral and negative images shown to them when they saw the instructional cue "Look" or to use emotion regulation strategies that made themselves feel less negative (i.e., distraction, reappraisal, or suppression) when they saw the cue "Decrease." Following the presentation of the images, participants subsequently rated their affective state on a 9-point Self-Assessment Scale (1 = *very good*, 5 = *no feelings*, 9 = *very bad*). We provided a brief illustration of different emotion regulation strategies before the experiment. Participants were also told that they could ask the experimenter if they did not understand these strategies. Then the experimenter was given a specific example (e.g., reappraisal: assuming the perspective of a medical professional during watching an instructional picture or focusing on technical aspects of the picture, suppression: keeping their face still while viewing pictures so that someone watching their face would not be able to detect what was being experienced subjectively) to ensure correct understanding of these strategies. After each run, participants were required to rate the extent to which they had used emotion regulation strategies during the task (i.e., task strategy use), using a scale ranging from 0 (*not at all*) to 9 (*extremely*). These self-assessments aimed to capture the participants' subjective perceptions of their utilization of different emotion regulation strategies during the task. To derive a comprehensive indicator of emotion regulation during the task, we calculated the mean scores across all runs for each participant, representing their overall tendency to employ specific strategies throughout the experimental session. To ensure that experimental instructions can be understood, participants additionally practiced several trials on their own before taking part in the actual experimental task.

We used a typical cued task-switching paradigm to assess participants' cognitive flexibility (Ravizza & Carter, 2008). The experiment consisted of two kinds of cues (green and blue) and two types of responses (judging the parity or size of numbers). Participants performed a task switch requiring them to change a cue–response set. Specifically, in each trial of the cued switch task, participants were presented with a single number on the screen and were required to respond based on the color cue. When the number was blue, participants were required to judge its magnitude and press the F key for numbers less than 5 and the J key for numbers greater than 5. When the number was green, participants were required to judge its parity and press the F key for odd and the J key for even numbers. Cue–response mapping and key operation were counterbalanced across the subjects. Based on whether the color rule keeps or switches between successive trials, two types of trials can be distinguished: repeat trials and switch trials. Following prior guideline reports, the overall probability of repeat and switch trials was set to 75% and 25%, respectively. We recorded the participants' response time (RT) for both the repeat and switch trials. A switch cost score was calculated for each participant according to standard procedures by subtracting mean RTs in correct repeat trials from mean RTs in correct switch trials (RT switch cost = RT switch − RT repeat). Quick and accurate completion of the switch condition (a lower switch cost) indicates a higher cognitive flexibility of the participants.

The order of two measurement tasks was randomized across participants. Additionally, a 15-min interval was allotted between the two tasks to allow participants to fully rest and minimize the potential impact of fatigue or emotional priming. This design aimed to ensure that each participant approached both tasks with comparable levels of energy and emotional state, minimizing any confounding factors that may obscure the assessment of cognitive flexibility.

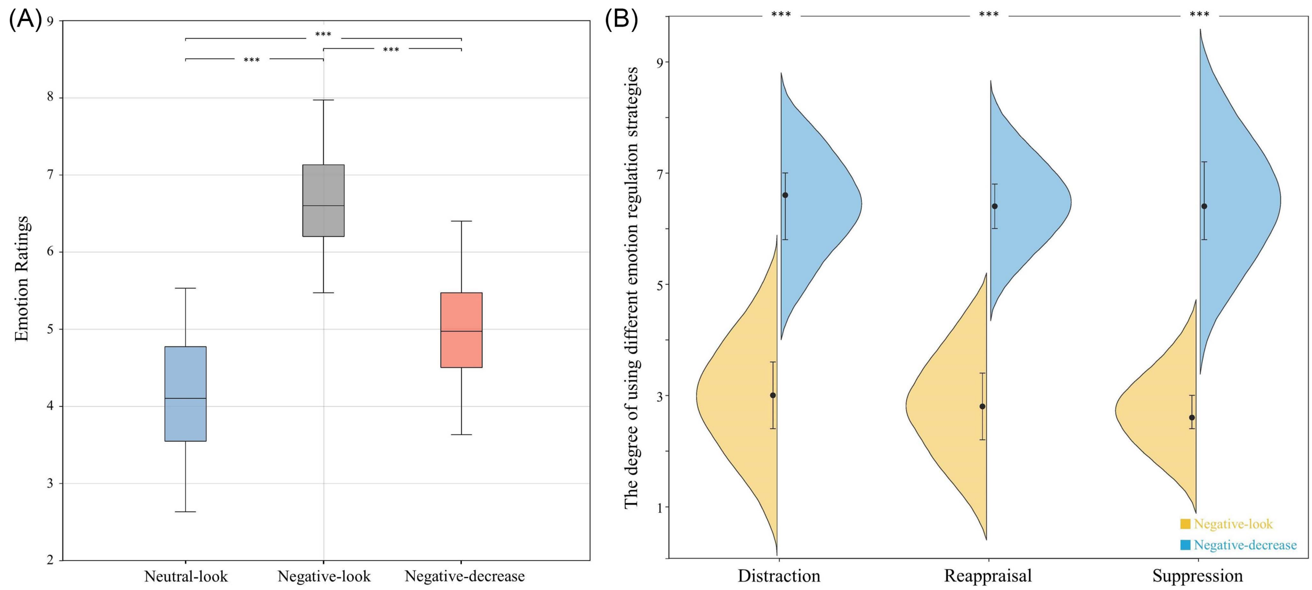
Results

We first tested the effectiveness of emotion induction and emotion regulation. We performed a one-way analysis of variance (ANOVA) of three conditions with cues, including neutral look, negative look, and negative decrease. As expected, we found significant differences across the three conditions, $F(2, 84) = 1132.76$, $p < .001$, $\eta^2 = .93$. Follow-up comparisons indicated that participants experienced more negative feelings in the negative-look ($M = 6.69$, $SE = .07$) than in the neutral-look conditions ($M = 4.09$, $SE = .08$), $p < .001$, 95% CI [2.46, 2.74]. In addition, participants experienced smaller negative feelings in the negative-decrease compared to the negative-look conditions ($M = 4.98$, $SE = .07$; $p < .001$, 95% CI [1.56, 1.84]; Figure 1A).

Moreover, we ran a repeated measures ANOVA with cue (look, decrease) and regulatory strategy (distraction, reappraisal, suppression) as within-subject factors. There was no main effect of emotion regulatory strategy, $F(2, 84) = 1.15$, $p = .321$, $\eta^2 = .01$ (Figure 1B), and no significant interaction between cues and regulatory strategy, $F(2, 84) = 2.63$, $p > .05$, $\eta^2 = .03$. However, there was a significant main effect of cue, $F(2, 84) = 3064.94$, $p < .001$, $\eta^2 = .98$. Follow-up comparisons showed that participants had higher ratings of regulatory strategy use (distraction, reappraisal, and suppression) in decrease than in look cue conditions. These results confirmed the manipulation effectiveness of emotional reactivity and emotion regulation.

Following the manipulation check, we used Pearson correlations analysis to test the association between cognitive flexibility and different emotion regulation strategies. There was no significant correlation between switch costs and task strategy use distraction ($r = -.18$, $p = .10$) or between switch costs and task strategy use suppression ($r = 0.02$, $p = .88$). However, we found switch costs were negatively correlated to task strategy use reappraisal ($r = -.38$, $p < .001$), which are consistent with prior findings that cognitive flexibility facilitates successful implementation of reappraisal. To confirm the above association, we also examined the correlation

Figure 1
The Comparison of Emotion Ratings and Strategy Use



Note. (A) Emotion ratings during the neutral-look, negative-look, and negative-decrease conditions are shown. (B) The comparison of strategy use between look and decrease conditions for each strategy (distraction, reappraisal, suppression) are shown. See the online article for the color version of this figure.
*** $p < .001$.

between switch costs and reappraisal measured by the ERQ, and the negative correlation was replicated ($r = -.33$, $p = .002$; see Supplemental Materials). Thus, cognitive flexibility was correlated with reappraisal, suggesting a necessity of taking reappraisal as a control variable in latter examination of situation covariation and goal adaptiveness of ERF.

Study 1

Since people need to cope with different situations and goals in daily life, situation covariation and goal adaptiveness of ERF were considered two critical factors in the relationship between cognitive flexibility and depression (Aldao et al., 2015). Therefore, Study 1 examined the roles of situation covariation and goal adaptiveness in the association between cognitive flexibility and depression using two experiments. Considering the observed correlation of cognitive flexibility and reappraisal above, participants were required to fill out the Chinese version of the ERQ as a control variable for subsequent analysis.

Experiment 1

To quantify the covariation of regulatory strategy with situation, participants performed a strategy selection task in changing situations and were asked to adjust their emotion regulation strategy as soon as possible. To assess the situation covariation of ERF, we recorded the response time difference between situation appearance and strategy selection to measure the degree of temporal consistency between the selection of regulatory strategy and situation change.

Method

Participants and Materials

We conducted a priori power analysis to determine the required sample size for this experiment (Blaise et al., 2016). We computed the required sample size using G*Power 3.1 (Faul et al., 2009) with parameters set to $r = 0.3$, $\alpha = .05$, $1 - \beta = 0.9$ (https://gpower.software.informer.com/3.1/). The required total sample size was estimated at 109 participants. One hundred twenty volunteers (63 females; $M_{age} = 22.58$ years, $SD = 3.53$ years) participated in Experiment 1. The sample size was sufficient to examine the correlation between cognitive flexibility and the situation covariation of ERF. We also measured participants' depressive levels using the Beck Depression Inventory (BDI-II; Beck et al., 1961), whose Cronbach's α was .91 in the present study. Using this measure, we examined the relationship between cognitive flexibility, depression, and situation covariation of ERF. All participants signed the written informed consent and were paid for their participation. This study was approved by the local ethical committee of Southwest University (IRB No. H19020).

We selected pictures and distinguished two types of negative situations to set up the condition of situation change, including fear and disgust. These pictures were taken from the internet. All negative pictures were pretested for arousal and valance. Both fear ($M = 6.51$, $SE = .16$) and disgust pictures ($M = 6.46$, $SE = .16$) were significantly more arousing than neutral pictures, $M = 4.02$, $SE = .13$; $F(2, 58) = 89.35$, $p < .001$, $\eta^2 = .76$. For valence ratings, both fear ($M = 7.06$, $SE = .19$) and disgust pictures ($M = 7.21$, $SE = .18$) led to significantly higher scores than neutral images, $M = 4.19$, $SE = .11$; $F(2, 58) = 91.44$, $p < .001$, $\eta^2 = .76$. Also, we pretested the degree of fear and disgust for both sets of pictures. The results showed that the fear pictures (M = 6.69, SE = .19) led to more fearful feelings than disgust pictures, $M = 5.42$, $SE = .13$; $d = 1.26$, $t(29) = 13.76$, $p < .001$, 95% CI [1.07, 1.45], while disgust pictures ($M = 6.67$, $SE = .20$) led to more disgust feelings than fear pictures, $M = 5.50$, $SE = .12$; $d = 1.37$, $t(29) = 11.93$, $p < .001$, 95% CI [1.13, 1.60]. In addition, we controlled the size, brightness, complexity, and resolution of all pictures before the experiment.

Situation Covariation of ERF

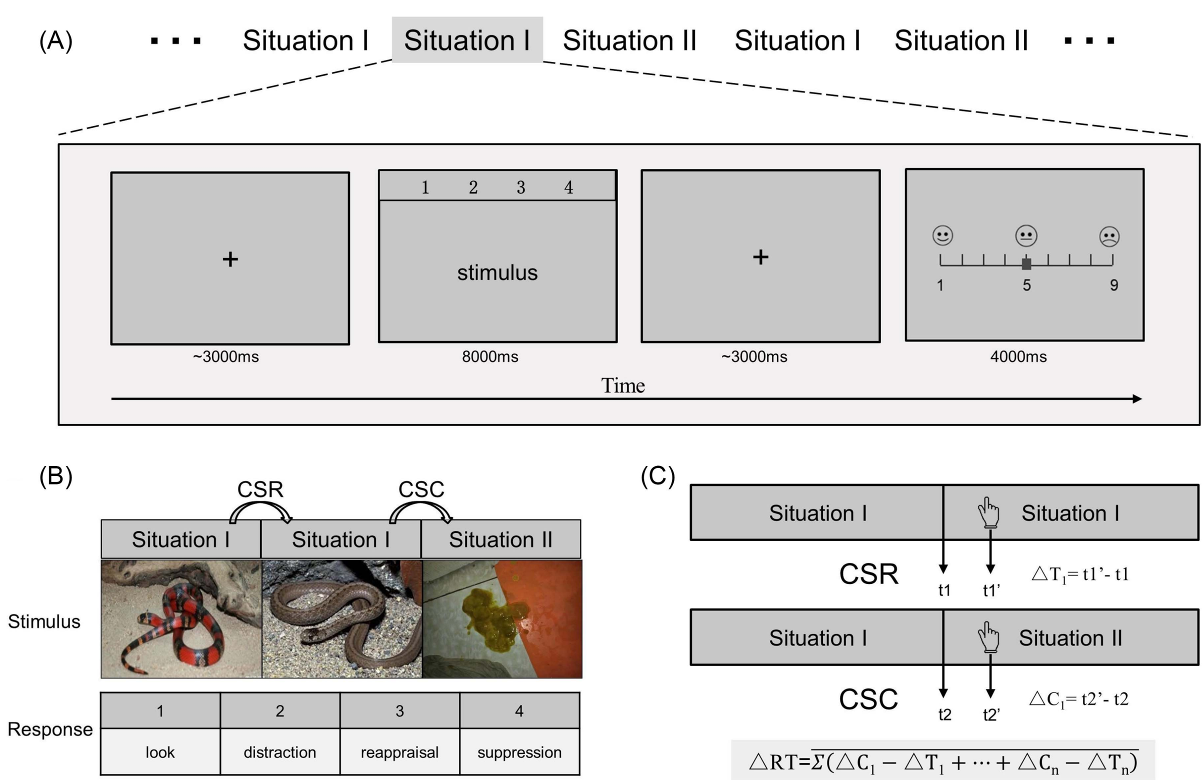
The experimental procedure is shown in Figure 2A. In each trial, participants were presented with an emotional stimulus ("fear" or "disgust") for 8 s and were asked to quickly select one out of three emotion regulation strategies to decrease negative feelings. Different emotion regulation strategies (distraction, reappraisal, suppression) were presented at the top of each picture for participants to choose from. Considering that previous studies have suggested that individuals may default to viewing without instruction (Suri et al., 2015), we also included "look" as the default option in the experiment. Following each image presentation, participants subsequently rated their affective state on a 9-point Self-Assessment Scale (1 = *very good*, 5 = *no feelings*, 9 = *very bad*). We distinguished two conditions in the experiment: (1) Congruent emotional stimuli in adjacent trials were identified as the conditions of situation repeat; we recorded the time point $t1$ of emotional stimulus presentation and $t1'$ of strategy selection in the situation-repeat trial. (2) Incongruent emotional stimuli in adjacent trials were identified as the conditions of situation change; we recorded the time point $t2$ of emotional stimulus presentation and $t2'$ of strategy selection in the situation-change trial (Figure 2B). Moreover, we calculated the difference between response time of conditions of situation repeat ($\Delta T_1 = t1' - t1$) and that of conditions of situation change ($\Delta C_1 = t2' - t2$). The degree of time covariation between situation change and the use of regulatory strategy can be quantified by the formula: $\Delta RT = \overline{\sum(\Delta C_1 - \Delta T_1 + \cdots + \Delta C_n - \Delta T_n)}$, which assesses situation-dependent emotion regulation (Figure 2C). To help subjects understand the experimental operation, participants additionally practiced several trials on their own before taking part in the actual experimental task.

Results

We first examined whether the pictures of fear and disgust induced significant negative emotional experiences of three conditions with cues, including neutral, fear, and disgust. As expected, there was a significant main effect of picture type, $F(2, 119) = 190.94$, $p < .001$, $\eta^2 = .62$. Follow-up comparisons indicated that both fearful pictures (M = 6.57, SE = .11) and disgust pictures (M = 6.78, SE = .09) evoked more negative feelings than the neutral pictures ($M = 4.58$, SE = .08), while the former two conditions showed no significant differences.

Figure 2

(A) Example Trial Sequence of the Strategy Selection Task, (B) The Experimental Response and Conditions, and (C) The Measurement Indicators and Calculation Methods of Situation Covariation



Note. CSR = conditions of situation repeat; CSC = conditions of situation change; t = time point; T = Time. See the online article for the color version of this figure.

We next conducted a manipulation check of adjusting regulatory strategies. One-way ANOVA with regulatory option (look, distraction, reappraisal, and suppression) showed a significant difference across the four strategies, $F(3, 476) = 687.54$, $p < .001$. Post hoc tests for pairwise multiple comparisons showed a lower frequency of selecting look options ($M = 5.35$, $SE = .23$) than distraction ($M = 18.60$, $SE = .25$; $d = -13.25$, $p < .001$, 95% CI [−14.32, −12.18]), reappraisal ($M = 18.18$, $SE = .24$; $d = -12.83$, $p < .001$, 95% CI [−13.80, −11.86]), and suppression ($M = 17.87$, $SE = .27$; $d = -12.52$, $p < .001$, 95% CI [−13.59, −11.44]), which indicated that participants adjusted their emotion regulation strategies despite the availability of a default option in the experiment. However, results of multiple comparisons indicated that there was no statistically significant difference between distraction, reappraisal, and suppression.

The correlation analysis showed that increased switch costs (denoting lower cognitive flexibility) were related to higher BDI scores ($r = .40$, $p < .001$). Moreover, we assessed the situation covariation of ERF by quantifying the temporal covariation between situation change and the variation of emotion regulation strategies. However, we did not find significant correlations between switch costs and situation-ΔRT ($r = .12$, $p = .192$). Using cognitive reappraisal measure of ERQ as a covariable did not alter this statistic ($r = .07$, $p = .431$). In addition, we conducted a mediation analysis to explore the relationship between cognitive flexibility, depression, and situation covariation of ERF using the PROCESS macro developed by Hayes (2012; https://www.processmacro.org/). The results showed no significant mediation effects. Thus, the situation covariation of ERF may not benefit from cognitive flexibility.

Discussion

Cognitive flexibility is the ability to adapt one's thinking and behavior in response to changing circumstances or new information. It allows individuals to shift their perspectives, adjust their emotional reactions, and utilize various coping strategies more effectively. Emotion regulation is a multifaceted process that involves not only the choice of a strategy but also the ability to implement that strategy effectively. Cognitive flexibility enables individuals to select the most appropriate coping mechanism based on their current emotional state, the specific situation, and the cognitive appraisal of that situation. This adaptability is essential, but it goes beyond mere temporal consistency. Previous studies suggest that cognitive flexibility involves various brain regions associated with decision making, emotional processing, and cognitive control. This interplay between cognitive and emotional processes can create a unique dynamic that is not solely based on the timing or consistency of strategies. Instead, it reflects a more integrated approach to regulating emotions that considers cognitive processes, goal pursuit, and contextual factors simultaneously. Therefore, the impact of cognitive flexibility on emotion regulation may not solely be explained by the alignment of emotion regulation strategies with the temporal context of changing situations.

Experiment 2

To quantify the goal adaptiveness of ERF, we measured the achievement of different goals during emotion regulation in Experiment 2. Participants were asked to complete a dual goal-pursuit task, and we recorded the performance of different goals to assess the goal adaptiveness of ERF.

Method

Participant

We recruited 120 college students for Experiment 2. Due to discomfort with the pictures, three participants dropped out, leaving 117 participants in the final sample (60 females; $M_{\text{age}} = 23.56$ years, $SD = 2.97$ years). The required total sample size was estimated at 109 by using G*Power 3.1 with parameters set to $r = 0.3$, $\alpha = .05$, $1 - \beta = 0.9$. Therefore, 117 participants in this experiment were still sufficient to examine the correlation between cognitive flexibility and goal adaptiveness of ERF. Participants need to perform a cued task-switching paradigm and were asked to fill out the BDI-II. Similarly, the ERQ scores were taken as covariable for the subsequent statistical analysis.

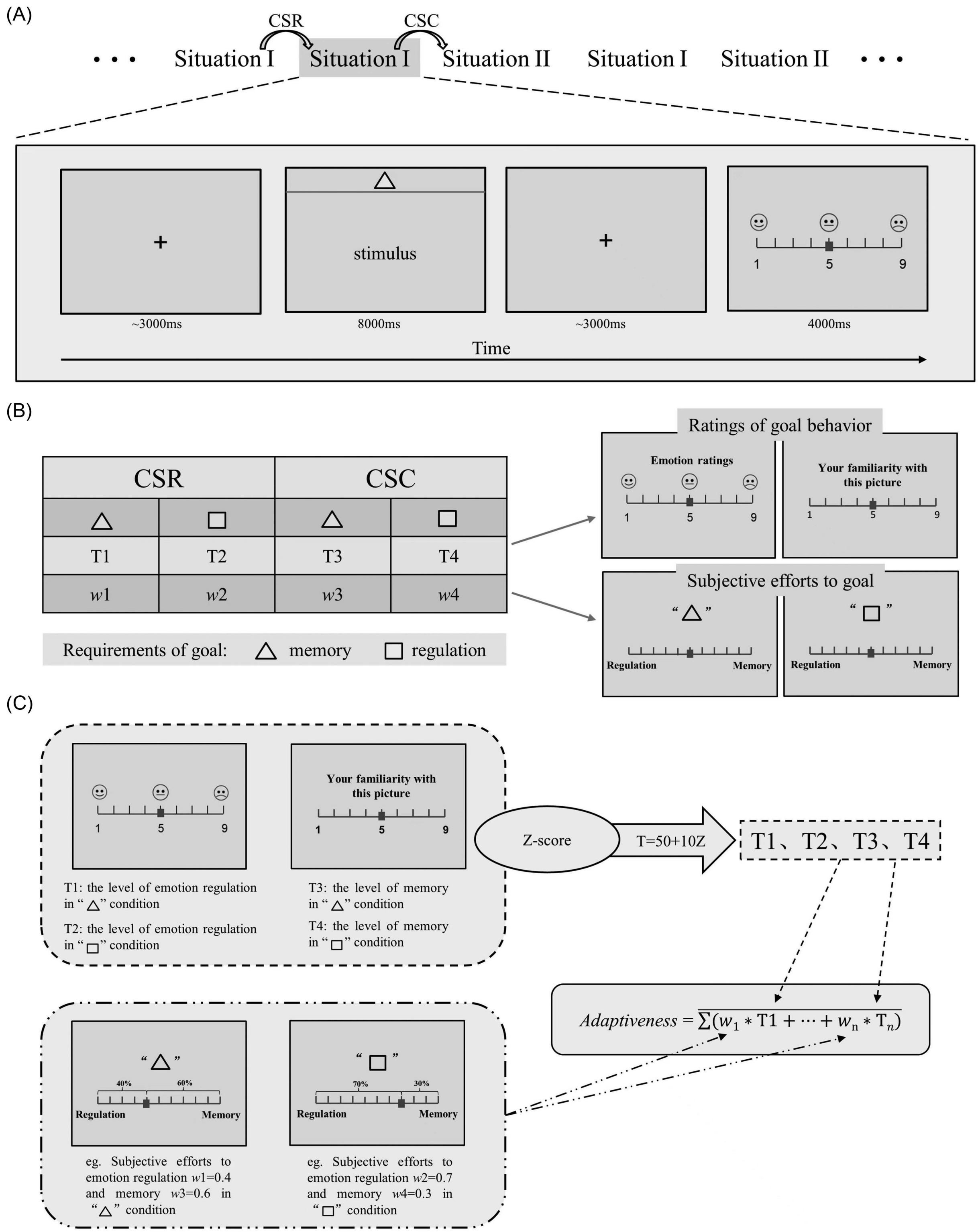
Goal Adaptiveness of ERF

The experimental design was shown in Figure 3A. Emotional materials and the condition of changing situations were the same as in Experiment 1. The difference was that we set two different goals, including emotion regulation goals (□: regulation) and nonemotion regulation goals (Δ: memory). In each trial, participants were presented with different goals ("□" or "Δ") at the top of each picture ("fear" or "disgust") and were asked to complete regulation or memory task according to the goal. Following each image presentation, participants rated their affective state on a 9-point Self-Assessment Scale (1 = *very good*, 5 = *no feelings*, 9 = *very bad*). The differences in emotion ratings between negative and neutral pictures were used to measure the achievement of emotion regulation goals in two conditions. After 30 min, participants were required to finish a picture retrieval task and rated their familiarity with the pictures on a 9-point scale (1 = *very unfamiliar*, 5 = *uncertain*, 9 = *very familiar*), a memory rating procedure used to quantify the achievement of nonemotion regulation goals in two conditions. In this experiment, we recorded participants' actual performance as T scores, including emotion rating and memory rating under different goals, which reflect the achievement of different goals for each condition (see Figure 3B).

Following each run, participants were asked to assess their efforts to regulate emotions or remember pictures under different goals, recorded as w by using a percentage scale. Specifically, participants need to move the cursor to allocate their effort within two goals. For example, if a participant moved the cursor position as shown in Figure 3C, the participant's w ratings indicated the effort of memory under "Δ" goal is 60%, and the effort of regulation under "Δ" goal is 40%, while the effort of memory under "□" goal is 30%, and the effort of regulation under "□" goal is 70%. Moreover, $w \times T$ assessed the level of adaptiveness for each goal, that is, individuals with higher $w \times T$ scores reflected better performance with personal goal-driven behavior. Therefore, we used the formula: goal adaptiveness $= \overline{\sum (w_1 \times T_1 + \cdots + w_n \times T_n)}$, to calculate the overall performance of both emotion regulation and nonregulation goals, which assessed the achieved outcomes of different goal-driven behaviors in this experiment (see in Figure 3C). The operation was consistent with the previous guidance; participants additionally

Figure 3

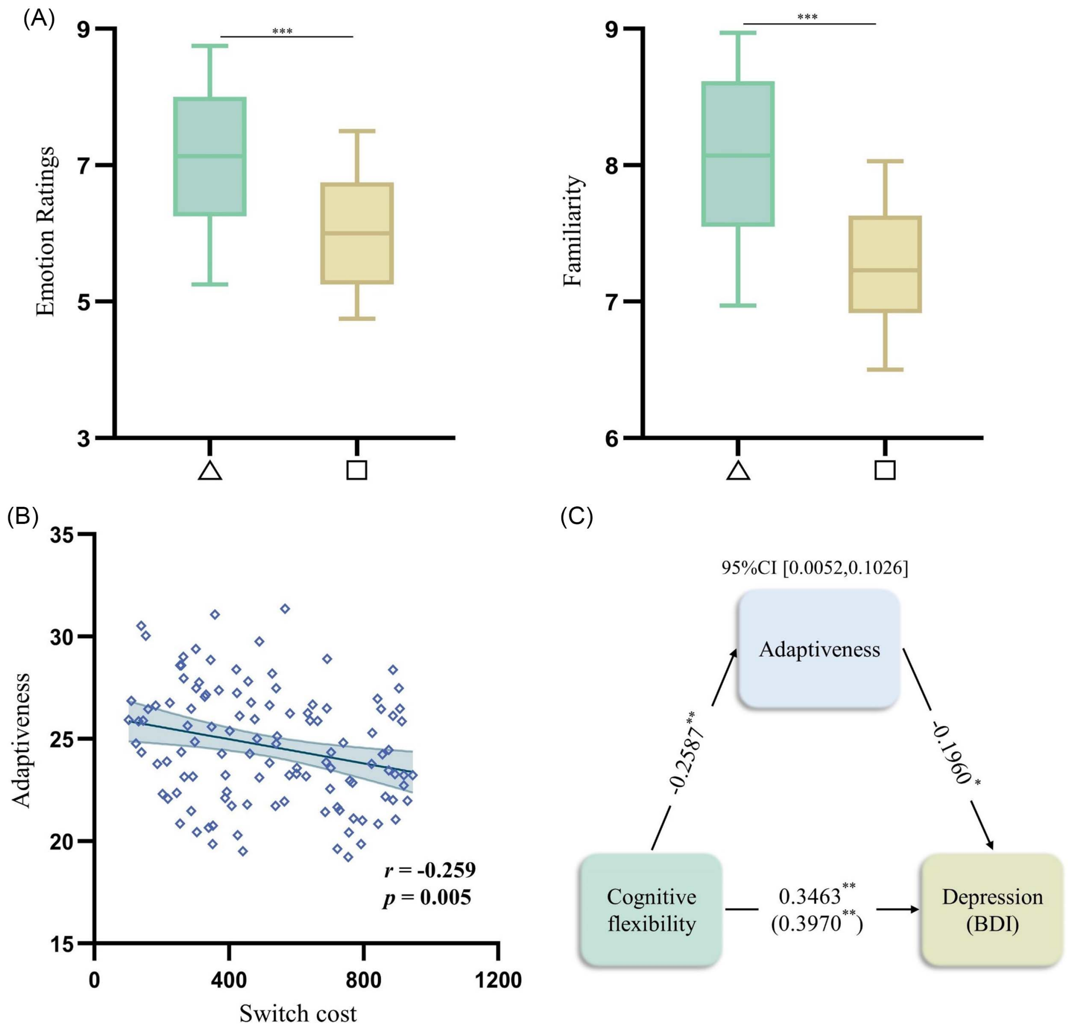
(A) Example Trial Sequence of the Dual Goal-Pursuit Task, (B) The Experimental Conditions and Measurements, and (C) The Calculation Methods of Goal Adaptiveness



Note. CSR = conditions of situation repeat; CSC = conditions of situation change; *w* = one's efforts to goals; *T* = Time.

Figure 4

The Correlation and Mediation Results of Goal Adaptiveness and Depression



Note. (A) Paired-samples *t* tests to the conditions of different goals (Δ: memory, □: regulation). (B) The correlation analysis between switch cost and goal adaptiveness scores. (C) The mediation analysis results of cognitive flexibility, goal adaptiveness, and depression scores. CI = confidence interval; BDI = Beck Depression Inventory. See the online article for the color version of this figure.

* $p < .05$. ** $p < .01$. *** $p < .001$.

practiced several trials on their own before taking part in the formal experiment.

Results

We first confirmed the main effect of emotional reactivity, showing that fear and disgust pictures induced more negative feelings compared to neutral pictures. Paired-sample *t* tests were next conducted to test whether emotion ratings and memory scores differed between goal conditions. As expected, participants showed lower emotion ratings in "□" condition and higher memory scores in "Δ" condition (Figure 4A), suggesting that participants followed the requirements of different goals in the experiment.

The correlation analysis showed that switch costs were significantly correlated to BDI scores ($r = .39$, $p < .001$) and adaptiveness scores ($r = -.26$, $p = .005$; Figure 4B). Moreover, we included the cognitive reappraisal scores of ERQ as a covariable, and the partial correlation remained significant for BDI ($r = -.23$, $p = .013$) and for adaptiveness ($r = -0.222$, $p = .017$) after reappraisal tendency was controlled. These results indicate that higher cognitive flexibility is associated with greater effectiveness of meeting different goal demands.

Finally, we performed a mediation analysis to explore the relationship between cognitive flexibility, depression, and goal adaptiveness. Results showed a significant indirect effect between switch costs and BDI scores through the goal adaptiveness scores

Table 1
The Indirect Effects of Cognitive Flexibility on Depression Through Goal Adaptiveness (ERQ as Covariable)

Mediator	Indirect effect	*SE*	95% CI (BC) *LL*	95% CI (BC) *UL*
$\text{Adaptiveness}_{(\text{uncontrolled})}$	0.0507	0.0255	0.0052	0.1026
$\text{Adaptiveness}_{(\text{controlled})}$	0.0427	0.0228	0.0033	0.0919

Note. ERQ = Emotion Regulation Questionnaire; *SE* = standard error; CI = confidence interval; BC = bias corrected; *LL* = lower limit; *UL* = upper limit.

(see Figure 4C). The mediation analysis was based on a standard three-variable path model and with a bootstrap test for the statistical significance of the indirect effect (MacKinnon et al., 2004). We calculated a bootstrap estimate of the indirect effect between the independent variable and dependent variable, an estimated standard error, and 95% CI for the population value of the indirect effect. Before conducting analyses, all variables were *z*-scored to produce standardized β weights. These results indicated that the goal adaptiveness of ERF explains a part of the association between cognitive flexibility and depression. Details about the mediation analysis are shown in Table 1.

Discussion

There are several reasons why the impact of cognitive flexibility on depression might be attributed to goal adaptiveness of ERF. First, our daily life is filled with varied emotional demands, necessitating constant reassessment and adjustment of goals. Cognitive flexibility enables individuals to modify their goals as situations evolve, allowing them to select emotion regulation strategies that align more closely with their current goals. Second, people often face challenges that require effective goal-directed problem solving to regulate their emotions successfully. Cognitive flexibility encourages the exploration of multiple solutions and strategies, allowing individuals to assess the most effective approaches for their changing goals. Finally, cognitive flexibility contributes to psychological resilience by encouraging the evaluation and modification of one's goals in the face of adversity. When individuals encounter setbacks or emotional distress, cognitive flexibility empowers them to redefine their goals and adjust their emotional responses accordingly. This approach not only aids in coping with immediate challenges, but it also bolsters long-term emotional regulation skills, enhancing overall well-being. Therefore, the association between cognitive flexibility and goal adaptiveness of ERF may help alleviate symptoms of depression.

Study 2

Previous studies have applied a task-switching paradigm to train cognitive flexibility and found that task-switching training can transfer to untrained tasks and domains (Buttelmann & Karbach, 2017; Zinke et al., 2012). There is potential evidence suggesting that cognitive flexibility training may be an important factor in improving emotion regulation ability in depression (Hoorelbeke et al., 2016; Keshavan et al., 2014). Therefore, based on the results of Study 1, we further tried to improve situation covariation and goal adaptiveness of ERF by using a cognitive flexibility training task, and we tested differences between pretraining and posttraining of situation covariation and goal adaptiveness of ERF in subclinical depressive samples.

Experiment 3

Method

Participants

We recruited 100 participants who got scores >14 on the BDI-II by filling out an online electronic questionnaire and who were willing able to commit to participation in a 14-day computerized training program. All individuals were evenly assigned to the cognitive flexibility training or control group using a randomized number. Seven participants were excluded because they did not complete the training task as required or dropped out; the final sample included 93 participants. Full written informed consent was given by all participants prior to the experiment. The study was approved by the local ethics committee of Southwest University.

Procedure of Training

In the training group, we used a computerized self-adaption training program to allow individuals adjusting task difficulty voluntarily and thus maximizing their cognitive flexibility performance. A task-switching training task proven effective in previous studies was used (Cepeda et al., 2001; Koch et al., 2018). On each training day, the participants were required to complete a mixed-rule task three times (for a total daily test time of 30 min); difficulty of the task will be increased when the accuracy rate exceeds 80%. In the control group, the training task was a single-rule task to avoid frequent switching. The training program was implemented for 14 days in both training and control group, and it can be ensured that the training duration was the same, 30 min per day. The primary outcome variables were situation-ΔRT and goal adaptiveness assessed by the tasks in Experiments 1 and 2, respectively.

The differences in demographic variables and the baselines of personality traits and the use of emotion regulation strategies between the training and control group were tested by independent samples *t* test. Mixed model ANOVA was used to examine the training effects by testing the Group × Time interactions in the outcome measures. Following up the significant interaction in the two-factor ANOVA, the simple effect of training for either group was tested by performing paired-samples *t* tests. All analyses were performed using SPSS 25.0 software, and *p* values and partial η^2 values were calculated for evaluating statistical significance and effect size.

Results

The results of independent samples *t* tests showed no significant differences in the demographic variables, personality traits, and the use of emotion regulation strategies between the two groups (Table 2). We examined the change in switch costs of the training group over a period of 14 days. The results were presented in Figure 5A, which confirmed that cognitive flexibility increased with training. Moreover, we conducted a 2 (Group: training, control) × 2 (Time: pretraining, posttraining) mixed model ANOVA and found a

Table 2
Demographics and Baseline Measures

Measure	Train *M*	Train *SD*	Control *M*	Control *SD*	*t*	*p*
Gender (%female)	53.2		54.3			.91
Age	23.79	2.84	24.00	2.56	−.38	.71
Extroversion	39.30	4.80	37.70	5.89	1.44	.15
Neuroticism	35.15	6.41	34.24	6.32	.69	.49
STAI-S	43.00	7.28	45.46	7.32	−1.62	.11
STAI-T	43.50	5.57	44.74	6.31	−1.01	.31
BDI	21.13	4.08	21.80	3.93	−.81	.42
ERQ (reappraisal)	23.70	5.35	23.67	5.42	.03	.98
ERQ (suppression)	15.49	5.61	16.89	4.91	−1.28	.20

Note. ERQ = Emotion Regulation Questionnaire; STAI-S = State Anxiety Inventory; STAI-T = Trait Anxiety Inventory; BDI = Beck Depression Inventory.

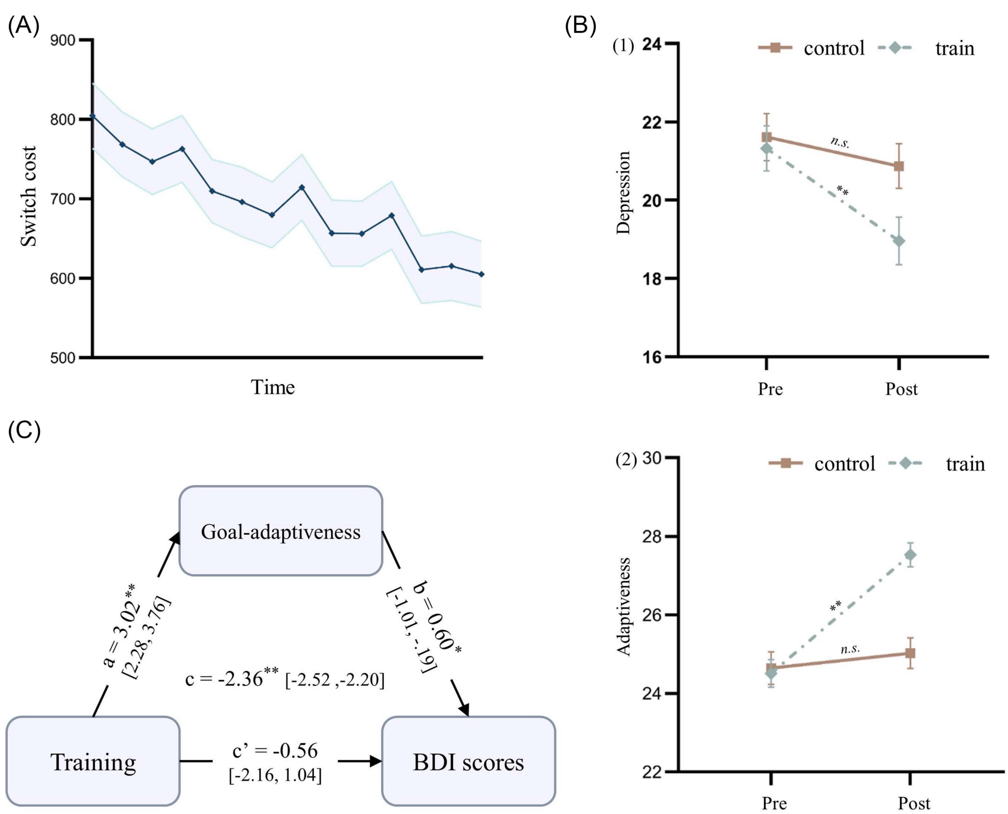
significant Group × Time interaction in depression scores, $F(1, 91) = 4.57$, $p = .03$, $\eta^2 = .05$; see Figure 5B (1). In addition, results of simple effects of time in each group indicated that the training group exhibited significantly lower depression scores at posttraining than at pretraining, $t(46) = -4.27$, $p < .001$, $d = -2.36$, 95% CI [−3.47, −1.25], while the depression of the control group did not differ across the training, $t(45) = -1.43$, $p = .161$, $d = -0.74$, 95% CI [−1.78, 0.31].

Similarly, a mixed design ANOVA also demonstrated a significant Group × Time interaction on the measure of goal adaptiveness, $F(1, 91) = 26.14$, $p < .001$, $\eta^2 = .22$ (Figure 5B [2]). However, there were neither significant Group × Time interaction, $F(1, 91) = .01$, $p = .977$, $\eta^2 = .001$, nor main effects of time, $F(1, 91) = .03$, $p = .87$, $\eta^2 < .05$ and group $F(1, 91) = .12$, $p = .73$, $\eta^2 < .05$, when the situation-ΔRT was used as the dependent variable.

The subsequent simple effect analyses for the goal adaptiveness measure indicated that the training group provided significantly greater goal adaptiveness scores at posttraining than at pretraining, $t(46) = 8.22$, $p < .001$, $d = 3.02$, 95% CI [2.28, 3.76], while the goal adaptiveness scores of the control group did not differ from pre- to posttraining, $t(45) = 1.03$, $p = .307$, $d = 0.38$, 95% CI [−.36, 1.11].

To further test whether the training effect of cognitive flexibility on depression is mediated by the effect on goal adaptiveness, we conducted a mediation analysis using bootstrapping procedure via MEMORE Macro for SPSS with 5,000 bootstrap samples (Montoya & Hayes, 2017). As expected, goal adaptiveness mediated the difference between pre- and posttraining on depression scores, which was indicated by the 95% CI for indirect effect ($B = 1.81$, $BootSE = .66$),

Figure 5
The Training Effect and Mediation Results



Note. (A) The alteration of switch cost over a period of 14 days. (B) The effects of cognitive flexibility training on depression (1) and goal adaptiveness scores (2). (C) The mediation analysis results of training effects, goal adaptiveness, and depression scores. BDI = Beck Depression Inventory; n.s. = no significance. See the online article for the color version of this figure.
* $p < .01$. ** $p < .001$.

which did not include 0 [.51, 3.11] (Figure 5C). These findings demonstrated that increased cognitive flexibility can improve goal adaptiveness of ERF and depressive symptoms, and the training effect in depression scores is mediated by increased goal adaptiveness after, compared to, before training.

Discussion

Task-switch training involves exercises designed to improve the cognitive process of alternating between different tasks or mental processes, guiding individuals to become more adept at shifting their attention and strategies as needed. Similarly, emotion regulation involves adjusting emotional responses to different situations, with the requirement to shift goals and strategies as circumstances change. Increased cognitive flexibility fosters a more agile mindset, allowing individuals to recognize when an emotional strategy is no longer effective and to pivot towards more suitable alternatives. Task-switch training can enhance this adaptability, enabling individuals to respond to emotional challenges more appropriately and effectively. Besides, individuals with depressive symptoms tend to engage in rigid or maladaptive thinking patterns, which can hinder their ability to adapt their emotional responses to new goals. Through task-switch training, individuals can learn to break free from these rigid patterns, allowing for more fluid and flexible thinking about their emotional experiences. This flexibility reduces the likelihood of falling into negative thought cycles often associated with depression.

Transparency and Openness

The study was preregistered on the Open Science Framework at https://osf.io/3khx9 (Gao, 2022), wherein we reported how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study. The data and materials are available in public projects on the Open Science Framework and are accessible at https://osf.io/498nk (Gao, 2024).

General Discussion

Situation Covariation and goal adaptiveness of ERF allow people to respond flexibly to changing environments, which can be facilitated by cognitive flexibility, and have been considered critical factors in coping with depression. In this study, we explored the effects of cognitive flexibility on situation covariation and goal adaptiveness of ERF and how they relate to the improvement of depressive symptoms through three experiments. First, preliminary experiment results showed that cognitive flexibility was associated with reappraisal and established the foundation for excluding the effects of emotion regulation strategies in subsequent experiments. Second, we observed that cognitive flexibility was not correlated to situation covariation of ERF, but it was significantly negatively correlated to goal adaptiveness of ERF through two experiments in Study 1. Finally, mediation analysis found that cognitive flexibility contributes to reduced depressive symptoms through enhanced goal adaptiveness of ERF, and this contribution could not be attributed to individual differences in habitual use of reappraisal. These findings shed light on how cognitive flexibility contributes to emotion regulation, which helps us understand the mechanism underlying maladaptive goal-pursuit processes of depression in daily settings.

In general, individuals with high levels of cognitive flexibility have a stronger function of cognitive control, which plays an important role in supporting the cognitive reappraisal process. Increased cognitive flexibility could facilitate the processing of environmental information and reduce cognitive costs during reappraisal, thus providing individuals with more possibility and effectiveness to engage in reappraisal (Malooly et al., 2013). For example, a recent study found that individuals with higher cognitive flexibility consumed fewer cognitive resources to achieve successful cognitive reappraisal in emotion regulation tasks (Zaehringer et al., 2018). Moreover, previous research also found that increased cognitive flexibility can help old adults enhance their cognitive restructuring ability (Johnco et al., 2013, 2014). Given that cognitive reappraisal requires changing the representation of the original semantic concept or schema (Buhle et al., 2014; Wallace-Hadrill & Kamboj, 2016), individuals with higher cognitive flexibility are likely to experience enhanced reappraisal processes due to their ability to quickly restructure semantic information. The intricate process of cognitive reappraisal, which entails the allocation of cognitive resources and the restructuring of mental representations, should benefit from heightened cognitive flexibility. This relationship may elucidate the observed outcomes from our preliminary experiment, suggesting that greater cognitive flexibility can facilitate the cognitive operations involved in effective reappraisal.

Moreover, in Study 1, we found cognitive flexibility was not correlated to situation covariation of ERF, but it was negatively correlated to goal adaptiveness of ERF when the effects of habitual reappraisal were controlled. This indicates the impact of cognitive flexibility on emotion regulation may be attributed to strategies facilitating the achievement of changing goals, rather than the temporal consistency of strategies with changing situations. On the one hand, emotion regulation is a process that unfolds over time, so processing input emotional information earlier can help individuals use strategies before emotions fully arise (Kalokerinos et al., 2017). Previous studies have shown that increased cognitive flexibility can facilitate the processing of input information (Braem & Egner, 2018; Moore & Malinowski, 2009), which supports the original hypothesis that the situation covariation of ERF can benefit from cognitive flexibility. However, to our surprise, we did not find a significant association between situation covariation of ERF with cognitive flexibility and depression. As Aldao et al. (2015) proposed, the covariation of situation and emotion regulation strategies does not consider situational demands, which may lead to maladaptive outcomes sometimes. For instance, several studies suggest that increased covariation of situations and strategies in the context of risk-taking tasks might lead to riskier decisions and ultimately negative emotional consequences (Heilman et al., 2010; van't Wout et al., 2010). On the other hand, although situation-ΔRT in this study may represent an individual's level of situation covariation of ERF, this indicator ignores differences in the time course of different emotion regulation strategies. Previous studies have found distraction, reappraisal, and suppression intervene at separate stages during emotion generation (Gross, 1998; Schönfelder et al., 2014). In addition, our results may also suggest a nonlinear relationship between situation covariation of ERF and depression, which supports the view that both excessively high and low levels of situation covariation are detrimental to mental health. Specifically, excessive situation covariation may lead to confusion and instability in coping strategies, while insufficient situation covariation may result in a lack of ability to cope with challenges and adversities, potentially increasing the likelihood of depression. These insights contribute to a deeper understanding of the complex interplay between emotion regulation flexibility and mental health, offering valuable implications for future research and clinical practice.

On the other hand, we observed a significantly negative correlation between cognitive flexibility and goal adaptiveness of ERF, which emphasized that the ability to pursue—and achieve—goals is an essential aspect of one's ability to interact successfully with the environment. Higher levels of cognitive flexibility enable us to shield current action goals from competing for distracting influences while simultaneously monitoring for potential context-relevant information (Bailly et al., 2012; Waskom et al., 2014). Several studies indicated cognitive flexibility is associated with contextual information processing efficiency and facilitates goal-pursuit behavior. For example, studies of creativity have found that increased cognitive flexibility can motivate individuals' goals and help process multiple goal-pursuit behaviors (Lin et al., 2014; Sligte et al., 2011). Moreover, prior studies also demonstrated the positive impact of cognitive flexibility on flexible goal adjustment, that is, cognitive flexibility helps in the adjustment of actions and thoughts to changing situations and goal demands (Dreisbach & Fröber, 2019). Besides, recent studies indicate that in persons with lower cognitive flexibility who suffer from a brain injury, their goal adjustment ability might be impaired, which leads to decreased mental health and well-being (Hajek & König, 2021; Van Bost et al., 2022). Additionally, evidence from implementation intention underlined that goal pursuit is an essential element of automatic emotion regulation, and a recent theoretical framework holds that goal adjustment plays an important role in emotion regulation processes (Huang et al., 2020; Pruessner et al., 2020). In line with these prior studies, we also found a significant mediation effect of goal adaptiveness scores on the relationship between cognitive flexibility and depression. Depressed individuals may struggle with setting, balancing, and pursuing achievable goals, as their cognitive flexibility is compromised, making it difficult for them to adjust their thinking patterns, adapt to changing circumstances and hinder their motivation/ability to engage in goal behaviors effectively. This combination of lower cognitive flexibility and reduced goal adaptiveness contributes to the maladaptive goal-directed processes observed in individuals with depression.

Furthermore, in Study 2, we also found increased goal adaptiveness scores in subclinical depression through cognitive flexibility training, but there was no significant alteration of situation covariation between pre- and posttraining. Previous studies indicated that individuals' goal-driven processes are more clearly directed compared to the processing of situational information and may be more susceptible to the dominance of cognitive control, which can be promoted by cognitive flexibility training (Benita et al., 2021; Eldesouky & Gross, 2019). Moreover, several studies indicated that when asked to use emotion regulation strategies, individuals with emotional disorders showed no worse performance compared to healthy people (Liu & Thompson, 2017; Quigley & Dobson, 2014). For instance, researchers found that depressive individuals can successfully use reappraisal and distraction to improve negative feelings under instruction (Ehring et al., 2010). However, a lower tendency and frequency of emotion regulation have been found in depression, which is attributed to abnormal emotion regulation motivation (Dryman & Heimberg, 2018; Everaert & Joormann, 2020). Moreover, it is demonstrated that motivation is closely associated with the process of goal pursuit, which is affected by cognitive flexibility (Aarts, 2007; Wright, 2016). Therefore, these results may account for subclinical depressive individuals' existing anomalous emotion regulation motivation, which highlighted the crucial role of goal adaptiveness in the relationship between cognitive flexibility and depression. Taken together, our findings confirm the theoretical speculation that if people want to ultimately benefit from emotion regulation, it is necessary for emotion regulation flexibility to facilitate the pursuit of personal goals, rather than solely focusing on improving flexibility.

Several limitations necessitate further investigation. First, although three strategies (distraction, reappraisal, and suppression) in this study are considered representative choices to investigate the adaptiveness of emotion regulation in response to changing situations and goals, a broader range of emotion regulation strategies should be included in future research to enhance ecological validity. Second, we did not consider the effectiveness of a specific strategy in different situations because this study primarily focused on the general responses of individuals in coping with changing situations and goals. As the appropriateness of a given strategy may vary across different situations, future study needs to investigate the situation-dependent flexibility and adaptiveness of a specific strategy. Third, considering that cognitive flexibility is a higher order cognitive function, the present study acknowledges the limitation associated with using a single measure to assess cognitive flexibility. A comprehensive measurement of cognitive flexibility should be used in future studies to confirm the validity and reliability of our findings. Fourth, since ratings of familiarity may not fully capture the participants' memory ability, more objective measurement methods (e.g., the variants of old/new test) could be developed in future work.

Conclusions

The present study explored the effects of cognitive flexibility on emotion regulation in depression by quantizing the processes of situation covariation and goal adaptiveness of ERF, which clarifies how it helps people flexibly regulate emotions to adapt to changing environments. Specifically, cognitive flexibility promoted emotion regulation in changing situations by facilitating goal adaptiveness rather than situation covariation of ERF. Moreover, cognitive flexibility training reduced depressive symptoms through increasing goal adaptiveness of ERF in subclinical depressed population. These findings suggest pathways for the intervention of psychopathological symptoms via increasing goal adaptiveness of ERF associated with cognitive flexibility.

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Received December 27, 2023
Revision received May 27, 2024
Accepted June 3, 2024 ■