Stress and Brain
https://doi.org/10.26599/SAB.2022.9060028 ISSN 2709-1325
RESEARCH ARTICLE

Buildup of implementation intention reduces anticipatory anxiety in a high-anxiety population

Dongmei Zhao[1,§], Hong Li[1,2,3,§], Jixuan Mao[1,3], Jiajin Yuan[1], Shengdong Chen[4], and Jiemin Yang[1] (✉)

[1] *The Affect Cognition and Regulation Laboratory, Institute of Brain and Psychological Sciences, Sichuan Normal University, Chengdu 610066, China*
[2] *Taiyuan Chengcheng Middle School, Taiyuan 030000, China*
[3] *Faculty of Psychology, Southwest University, Chonqqing 400715, China*
[4] *School of Education, Qufu Normal University, Qufu 237165, China*
[§] *Dongmei Zhao and Hong Li contributed equally to this work.*

ARTICLE INFO

Received: 19 April 2022
Revised: 21 November 2022
Accepted: 3 December 2022

© The Author(s) 2022

Creative Commons Non Commercial CC BY-NC: This article is distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 License (http://www.creativecommons.org/licenses/by-nc/4.0/) which permits non-commercial use, reproduction and distribution of the work without further permission.

KEYWORDS

anticipatory anxiety, implementation intention, emotion regulation, cue–target paradigm

ABSTRACT

Previous research demonstrates that the cue–target paradigm is effective in inducing anticipatory anxiety, whereas the setup of implementation intention is effective in relieving anticipatory anxiety in a healthy sample. However, exploring whether this method can reduce anticipatory anxiety symptoms in high-anxiety individuals is necessary. The response to this question is of importance to clinical application. For this reason, this study applied the cue–target paradigm to induce anticipatory anxiety to potential negative pictures in subjects classified as high- vs. low-anxiety individuals. In addition, subjects were instructed to receive implementation intention or no-regulation instructions to examine the variation in the regulatory effects of implementation intention according to the severity of anxiety. The results demonstrated that high-anxiety participants exhibited increased anticipatory anxiety during uncertain and negative cues compared with those of low-anxiety subjects. In addition, anticipatory anxiety was reduced during implementation intention relative to the control condition. The size of this reduction was similar between the high- and low-anxiety groups. Third, the buildup of implementation intention reduced the anticipatory anxiety of high-anxiety individuals to a level similar to that of low-anxiety individuals in the control condition. These results suggest that setting up implementation intention can effectively down-regulate the symptoms of anticipatory anxiety in a high-anxiety population.

1 Introduction

Scholars provided evidence that anticipation about potential future threats induce anxiety in multiple levels, which range from affective and cognitive to behavioral manifestations [1–3]. This phenomenon is called anticipatory anxiety. In real life, it is frequently characterized by potential unfavorable clues that signify future threats, such that people with anticipatory anxiety remain in

Address correspondence to yangjiemin85@126.com, yangjiemin@sicnu.edu.cn

a state of stress, including physiological arousal, cortical activation, and cognitive bias [4–6]. Recently, Zhao et al. demonstrated that the buildup of the if–then plan in implementation intention, which is a widely known form of automatic emotion regulation [7, 8], is effective in reducing anticipatory anxiety in the healthy population. This study designed three control comparison conditions, where the results confirmed that if–then contingencies (in addition to goal representation), instead of mere goal setup or goal–strategy combination, efficiently relieved anticipatory anxiety. However, the majority of subjects recruited for this study were emotionally stable, whereas few displayed obvious trait or state anxiety symptoms. To expand the clinical application of this method to affective rehabilitation, it is necessary to explore whether this method can be used for the intervention of anticipatory anxiety symptoms in high-anxiety individuals. The response to this question is not only important to potential clinical application, but is also important to clarifying the relationship between anxiety severity and the regulatory effect of implementation intention.

Implementation intention is based on the representation of goal intention and the employment of a specific implementation method to achieve the goal. Goal intention refers to one's intention to seek a specific goal, such as "I want to do Z." The implementing method frequently takes the form of an if–then plan. For example, to set up an implementation intention, people need to firstly establish a goal related to emotion regulation, such as "I will not feel disgusted." Thereafter, people need to specify a likely emotional or stressful situation and the manner of responding to this situation using a planned strategy, such as "If I see blood, I will take the perspective of a physician" [8, 9]. Practicing the goal and the if–then plan then leads to the formation of contingency between the *if* situation and the *then* response. In other words, the *then* component of the response will be automatically initiated upon the *if* situation to change cognition, emotion, or behavior in a fluent manner with less consumption of cognitive resources [10–12].

Many studies proposed that constructing implementation intention can help individuals effectively address negative emotions [9, 13, 14]. When viewing pictures of spiders, an amplitude of P100, a component considered to reflect attentional coding of arousing stimulus, is significantly compromised during the implementation intention compared to the control conditions [15]. It suggests that the potential down-regulation effect may occur in the early processing stage, where this strategy decreased emotional attention to negative pictures. Beyond the attention processing stage, Gallo et al. further found that only participants in the implementation intention group successfully reduced negative emotional responses compared with the control group and the goal intention group [15, 16]. Moreover, participants in the implementation intention group rated fearful pictures more positively with low levels of arousal and high levels of sense of control compared with the goal intention group. Azbel-Jackson et al. reported that when viewing threatening pictures (e.g., weapons), the electrical skin activity and heart rate of participants were significantly lower during the implementation intention condition compared those during the goal intention condition [17]. In addition, implementation intention can not only improve the explicit emotions of individuals but also influence implicit emotional responses [18], and even help to avoid the adverse effects of unpleasant emotions on risky behaviors [19].

Following the method of Zhao et al. [7], the current study used the cue–target paradigm to induce anticipatory anxiety in subjects with distinct regulatory strategy and anxious severity.

The specific process of the cue–target paradigm is as follows. An experimenter informs participants that negative events may occur afterward and that different cues indicate whether negative events will occur. The score for subjective anxiety was used to measure the intensity of anxiety upon the presentation of threat cues. As previously stated, the primary objective of this study is to explore the potential utilization of the buildup of interpretation intention to relieve anticipatory anxiety responses to threat cues in a high-anxiety population. As implementation intention has proven effective in regulating emotion arousal with little cognitive cost [9], we hypothesize this method should be effective in regulating anticipatory anxiety ratings in high-anxious population.

2 Method

2.1 Participants

The Self-Rating Anxiety Scale was used for screening high versus low levels of anxiety in a college student population [20]. A total of 895 questionnaires were collected out of which 843 were valid. The Self-Rating Anxiety Scale is a four-point scale composed of 20 items ranging from 1 = *no or very little time* to 4 = *most or all the time*. After data collection, the scores of the 20 items are summed to obtain the total score. Females are more sensitive to emotionally negative stimulus than males [21]. Thus, the current study only recruited female participants. Finally, according to the Chinese norm, 53 females (age: M = 19.56, SD = 1.08) with a total score of ≤ 29 were finally selected and recruited as the low-anxiety population, whereas 52 females (M = 19.77, SD = 1.20) with a total score of ≥46 were assigned as the high-anxiety population [20]. The participants in each group were randomly assigned under the control ($N_{\text{high-anxiety}}$ = 26; $N_{\text{low-anxiety}}$ = 27) and implementation intention ($N_{\text{high-anxiety}}$ = 26, $N_{\text{low-anxiety}}$ = 26) condition. The participants are right-handed, free of any diagnosis of clinical psychiatric disorders, without history of psychotropic or hormonal drug use, and with normal or corrected-to-normal vision. Each participant signed an informed consent form prior to the experiment.

To test the homogeneity of emotion-related measures across groups (control vs. implementation intention), we performed ANOVA with strategy (control or implementation intention) and population (high- vs. low-anxiety) as the independent variables, on the scores of several scales, including the State Anxiety Scale, Trait Anxiety Scale, Self-Rating Depression Scale, and the Self-Esteem Scale [20] as well as the habitual use of cognitive reappraisal and expressive suppression in the Emotion Regulation Questionnaire and the Acceptance and Action Questionnaire. The results demonstrated that the main effects of population on state anxiety was significant ($F_{(1, 101)}$ = 67.34, p < 0.001, η_P^2 = 0.40), trait anxiety ($F_{(1, 101)}$ = 141.33, p < 0.001, η_P^2 = 0.58), and depression ($F_{(1, 101)}$ = 122.79, p < 0.001, η_P^2 = 0.55), self-esteem ($F_{(1, 101)}$ = 38.16, p < 0.001, η_P^2 = 0.27), habitual use of cognitive reappraisal ($F_{(1, 101)}$ = 17.53, p < 0.001, η_P^2 = 0.15), habitual use of expression suppression ($F_{(1, 101)}$ = 24.81, p < 0.001, η_P^2 = 0.20), and acceptance and action ($F_{(1, 101)}$ = 53.75, p < 0.001, η_P^2 = 0.35). Alternatively, the main effects of strategy grouping ($F_{(1, 101)}$ = 0.02–1.91, p = 0.17–0.90) and strategy by population interaction ($F_{(1, 101)}$ = 0.02–2.57, p = 0.11–0.89) were non-significant for all measures. These results demonstrated that no significant differences exist between the control and implementation intention groups in terms of emotional state, emotional trait, and emotional regulatory tendency regardless of anxiety grouping. High-anxiety subjects exhibited significantly higher ratings on state anxiety ($F_{(1, 101)}$ = 67.34, p < 0.001), trait

anxiety ($F_{(1, 101)}$ = 141.33, p < 0.001), depression self-rating ($F_{(1, 101)}$ = 122.79, p < 0.001), and habitual expressive suppression ($F_{(1, 101)}$ = 24.81, p < 0.01) than those of low-anxiety subject but significantly lower ratings on acceptance and action ($F_{(1, 101)}$ = 53.75, p < 0.001), habitual use of cognitive reappraisal ($F_{(1, 101)}$ = 17.53, p < 0.001), and self-esteem rating ($F_{(1, 101)}$ = 38.16, p < 0.001) than those of low-anxiety subjects. Therefore, the current study was successful in randomly grouping the subjects into different strategic groups, where high-anxiety subjects were characterized by a number of psychosocial symptoms (e.g., high levels of depression, low levels of self-esteem, and maladaptive emotion regulation), as reported by previous studies (Fig. 1) [22].

2.1.1 *Stimuli*

Zhao et al. demonstrated the picture choice and validation procedure [7]. Briefly, the picture set used in the current study included 62 negative pictures (e.g., snakes, spiders, cockroaches, and bloody pictures) and 62 neutral pictures (landscapes), which were selected from the International Affective Picture System (IAPS) [23], the Chinese Affective Picture System (CAPS) [24], and the internet. Four pictures were used for practice, whereas the remaining 120 pictures were utilized for the formal experiment.

2.1.2 *Procedure*

The experiment procedure was basically the same as that used by Zhao et al. [7]. The instructions for the control and implementation intention groups were "In the following experiment, I will attend, feel and reveal my emotions naturally" and "I will not feel anxious. If the cue indicates negative picture, then I will remain calm and relaxed," respectively. The practice session included four trials, one negative picture for negative cues, one neutral picture for neutral cues, and one negative picture and one neutral picture under uncertain cues. To ensure that participants understood the meaning of each cue, they were instructed to write down the meaning of each cue on a paper, and the experiment would continue only when the content was written correctly. After practice trials, the formal experiment began, which included 120 trials divided by two blocks at 60 trials per block. Thus,

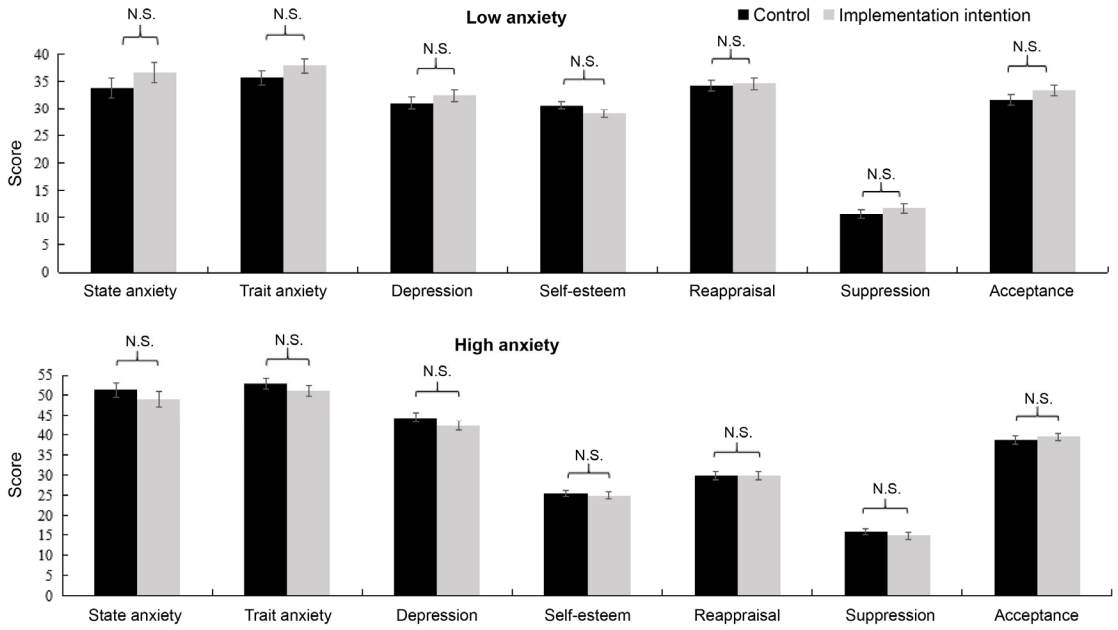

Figure 1 Averaged scores of state anxiety, trait anxiety, depression, self-esteem, and habitual use of emotion regulation measures (e.g., reappraisal, suppression, and acceptance) under different conditions and groups. N.S. = non-significant; error lines denote standard errors.

each block consists of 15 negative pictures after negative cues; 15 neutral pictures after neutral cues; and 15 negative pictures and 15 neutral pictures after uncertain cues. The four conditions above mentioned were presented randomly to participants in each block.

For each trial, the participant firstly focused on a cross on a screen for 500 ms, where a prompt cue would then be randomly presented for 4,000 ms. After the cue disappeared, the participants were asked to rate their experience of anxiety using a nine-point scale (1 = not anxious at all; 9 = very anxious) and press a corresponding key within 2,000 ms. Afterward, a picture corresponding to the cue will be presented for 4,000 ms. Following the picture, the participants rated the emotional valence (1 = very unpleasant; 9 = very pleasant) and arousal (1 = very calm and relaxed; 9 = very excited and nervous) of the picture. At the end of the experiment, the participants were asked to score the extent to which they followed the instructions during the experiment (1 = not at all; 9 = very much; Fig. 2).

3 Results

3.1 Effectiveness of data

To ensure that participants complied with the instructions, data that indicated low levels of compliance level (≤ 6) were excluded, such that the data of 87 were included for analysis (effective rate = 82.86%). ANOVA on compliance scores demonstrated that the main effect of the strategy (control condition and implementation intention condition; $F_{(1, 83)} = 0.24$, $p = 0.63$), the main effect of population (anxious and non-anxious population; $F_{(1, 83)} = 0.16$, $p = 0.69$), and the interaction effect of strategy × population ($F_{(1, 83)} = 3.76$, $p = 0.06$) were non-significant. Moreover, the study observed no significant difference in the degree of compliance with the instruction across groups.

3.2 Differences in anxiety induction between high- and low-anxiety groups

To verify whether the anticipatory anxiety rating differs between high- and low-anxiety groups, we firstly analyzed data under the control condition. Repeated-measures ANOVA on anxiety scores under the control condition demonstrated the significant main effect of the type of cue ($F_{(1.20, 51.69)} = 83.18$, $p < 0.001$, $\eta_p^2 = 0.66$). Among them, the anxiety score after negative cues ($M = 5.61$, SD = 2.02) was significantly higher than that after uncertain cues ($M = 4.65$, SD = 1.83, $p < 0.001$), which, in turn, elicited higher anxiety ratings than those for neutral cues ($p < 0.001$). The main effect of population ($F_{(1, 43)} = 5.68$, $p = 0.02$, $\eta_p^2 = 0.12$) was significant; the anxiety

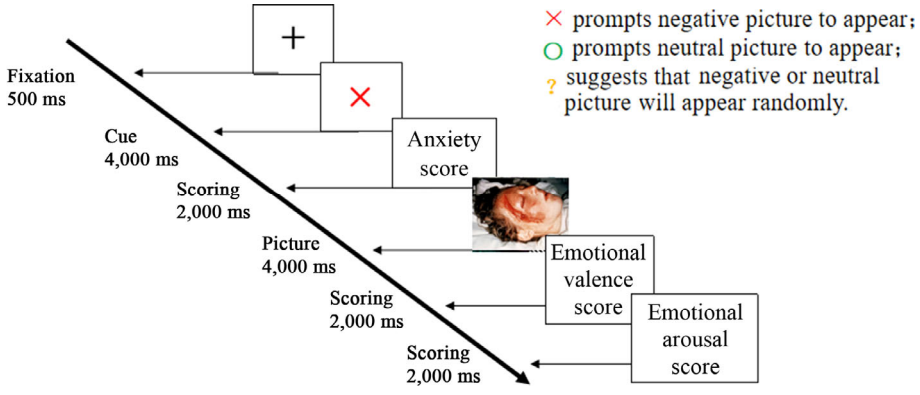

Figure 2 Streamline of experimental procedure. For each trial, the following six visual stimuli appeared successively: a fixation, a cue, anxiety scoring, a target picture, valence, and arousal scoring. Half of the trials included certain cues (negative and neutral cues), whereas the other half included uncertain cues.

scores of the low-anxiety population (M = 3.73, SD = 1.47) was significantly lower than those of the high-anxiety population (M = 4.80, SD = 1.47, p = 0.02). The interaction effect of population × cue type ($F_{(1.18, 98.71)}$ = 1.47, p = 0.24) was non-significant. These data indicate that, as hypothesized, the high-anxiety sample exhibited significantly higher anticipatory anxiety experiences than those of the low-anxiety sample. However, the above-mentioned effect of cue type exhibited a similar pattern for the high- and low-anxiety groups.

3.3 Effect of implementation intention on levels of anticipatory anxiety among the high-anxiety population

To test the effect of implementation intention on the levels of anticipatory anxiety in the high-anxiety population, we performed a separate ANOVA on anxiety scores for this group. The main effect of cue type ($F_{(1.20, 46.94)}$ = 73.82, p < 0.001, η_p^2 = 0.65) was significant (the same pattern as that observed in Section 3.2). The main effect of strategy ($F_{(1, 39)}$ = 21.03, p < 0.001, η_p^2 = 0.35) was significant, with the anxiety scores of the implementation intention group (M = 2.92, SD = 1.31) significantly lower than those of the control group (M = 4.80, SD = 1.31, p < 0.001). The interaction effect of strategy × cue type ($F_{(1.18, 98.71)}$ = 7.52, p = 0.006, η_p^2 = 0.16) was significant, which is attributed to the altered emotion regulation effect across different cuing conditions which was more pronounced during negative (p < 0.001) and uncertain cues (p < 0.001) than during neutral cues (p = 0.049; Fig. 3).

3.4 Rehabilitation effect of implementation intention on anxiety levels in the high-anxiety sample

To test the recovery effect of implementation intention on anxious population, we compared the anxiety scores of the high-anxiety sample during implementation intention and those of the low-anxiety sample under the control condition using mixed ANOVA (cue type (certain, uncertain, and neutral) × group (implementation intention in high-anxiety vs. low-anxiety control)). Except for the main effect of cue type (the same pattern as that in Section 3.2, $F_{(1.20, 50.25)}$ = 57.97, p < 0.001, η_p^2 = 0.58), we observed neither a significant main effect of group ($F_{(1, 42)}$ = 2.79, p = 0.10) nor a significant group × cue type interaction effect ($F_{(1.20, 50.25)}$ = 2.38, p = 0.13). This result denotes that implementation intention helped high-anxiety individuals to decrease anticipatory anxiety to the regular levels of low-anxiety individuals.

3.5 Mixed-design repeated-measure ANOVA on anticipatory anxiety

Repeated-measure ANOVA on anxiety scores were performed with strategy, population, and cue type as the independent variables. The

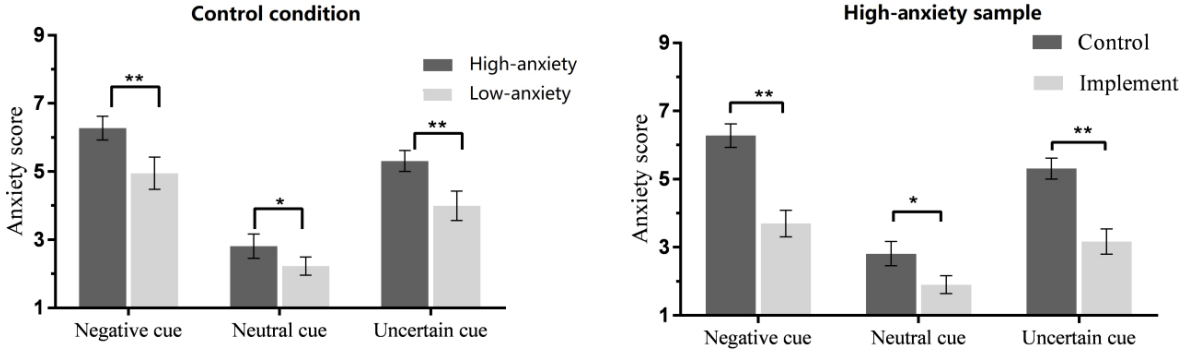

Figure 3 Elicitation of anticipatory anxiety responses across high- vs. low-anxiety individuals and the emotion regulation effects of implementation intention. Error lines denote standard errors; *p < 0.05, **p < 0.01.

results illustrated that the main effect of strategy ($F_{(1, 84)}$ = 22.26, p < 0.001, η_P^2 = 0.21) was significant with the anxiety score under the implementation intention condition (M = 2.78, SD = 1.47) significantly lower than that under the control condition (M = 4.26, SD = 1.47) (p < 0.001). In addition, the main effect of population ($F_{(1, 84)}$ = 4.64, p = 0.03, η_P^2 = 0.05) was significant with the anxiety score lower in the low-anxiety (M = 3.19, SD = 1.47) compared to the high-anxiety (M = 3.86, SD = 1.47, p = 0.03) population. In addition, the main effect of cue type ($F_{(1.18, 98.71)}$ = 121.55, p < 0.001, η_P^2 = 0.59) and the interaction effect of strategy × cue type ($F_{(1.18, 98.71)}$ = 8.71, p = 0.003, η_P^2 = 0.09) were significant. The breakdown of the strategy × cue type interaction demonstrated high levels of evident emotion regulation effect of implementation intention during negative (p < 0.01) and uncertain (p < 0.01) cues than those during neural cues (p = 0.05). The interaction effect of strategy × population ($F_{(1, 39)}$ = 1.62, p = 0.21, η_P^2 = 0.02) was non-significant, which suggests that implementation intention can decrease anticipatory anxiety to a similar strength for high- and low-anxiety populations.

3.6 Valence and arousal ratings for emotional pictures

The study conducted repeated-measure ANOVA on the valence scores with strategies (control and implementation intention), population (high- vs. low-anxiety), cue type (certain and uncertain cues), and picture type (negative and neutral) as the independent variables. The results indicated that the main effect of picture type was significant ($F_{(1, 84)}$ = 260.56, p < 0.001, η_P^2 = 0.76) and that the valence scores for negative pictures (M = 3.41, SD = 0.12) was lower than those for neutral pictures (M = 6.28, SD = 0.12). Moreover, the interaction effect of picture type × cue certainty was significant ($F_{(1, 83)}$ = 7.58, p = 0.007, η_P^2 = 0.08). The valence score for negative pictures under certain cues was significantly lower than that under uncertain cues (p = 0.007), whereas the valence scores for neutral pictures were non-significantly different between certain and uncertain cues. The main effects of strategy and population were non-significant (p_s > 0.05). In addition, the interaction effect of picture type × population or picture type × strategy was non-significant (p_s > 0.05). These results suggest that using implementation intention did not influence emotional ratings for pictures, whereas negative anticipation evoked by certain cues reinforced the emotion ratings of the subjects for negative pictures.

ANOVA on arousal ratings exhibited the main effect of picture type ($F_{(1, 84)}$ = 177.74, p < 0.001, η_P^2 = 0.68). The arousal score for negative pictures (M = 6.02, SD = 1.31) was significantly higher than that of neutral pictures (M = 3.56, SD = 1.49). Moreover, the main effect of strategy was significant ($F_{(1, 84)}$ = 11.49, p = 0.001, η_P^2 = 0.12), with arousal scores under the implementation intention condition (M = 4.40, SD = 1.14) significantly lower than those under the control condition (M = 5.18, SD = 1.14). The main effect of population was significant ($F_{(1, 84)}$ = 6.96, p = 0.01, η_P^2 = 0.08), and the arousal scores were significantly higher for the high-anxiety (M = 5.09, SD = 1.14) compared with the low-anxiety (M = 4.50, SD = 1.14) populations. The interaction effect of picture type × cue certainty was significant ($F_{(1, 84)}$ = 9.21, p = 0.003, η_P^2 = 0.10). Arousal scores for negative pictures after certain cues were significantly higher than those after uncertain cues (p < 0.01), whereas arousal scores for neutral pictures non-significantly differed under the certain and uncertain cue conditions (p > 0.10). The study observed no other significant interaction effects. These results imply that increased anxiety is associated with high arousal ratings for cue-preceded emotional pictures, whereas implementation intention can relieve

overall arousal for emotional pictures regardless of anxiety symptom and cue types.

4 Discussion

This study screened high- and low-anxiety individuals using self-rating anxiety, to explore the possibility of building up implementation intention to promote the efficient regulation of anticipatory anxiety among high-anxiety individuals. The current study used an experimental procedure that is basically the same as that of a previous study [7]. The only difference is that the participants were required to rate the valence and arousal of the target pictures at the end of each trial to explore the lasting effects of implementation intention. The results demonstrated that the high-anxiety population exhibited more intense anticipatory anxiety to potentially threat cues under conditions with negative and uncertain cues compared with the low-anxiety population. Meanwhile, implementation intention could effectively relieve the intensity of anticipatory anxiety in high-anxiety individuals even to a level similar to that of low-anxiety individuals.

The essential feature of individuals with anxiety is excessive negative expectations for future uncertain events [2]. In this sense, they overestimate the probability and the negative impact of potential future threats [2, 25]. Even when the probability of the occurrence of negative events is extremely small, they would still tend to experience high levels of anticipatory anxiety [26]. In an fMRI study, 14 high-anxiety participants and 14 healthy participants completed the anticipatory task for emotional pictures. The results revealed that the two groups of participants displayed greater activation of the bilateral anterior insula under aversion cues compared with pleasure cues, whereas the activation of the right insula was significantly higher in high-anxiety individuals compared with healthy individuals. This finding suggests that anxiety was related to high levels of anticipatory responsiveness to threats in the brain [3]. In addition, participants with comorbid depression or generalized anxiety disorder, compared with the control group, were associated with increased activation of the middle frontal lobe and insula, which are indicative of heightened anxiety responses [27]. Consistent with these studies, the current study illustrates that high-anxiety individuals displayed higher levels of anticipatory anxiety ratings compared with those of the low-anxiety sample.

Furthermore, the current study indicates that the pre-existing anxiety symptoms of the subjects do not influence the utility of building up implementation intention to regulate anticipatory anxiety. This notion further corroborates the generalizability of implementation intention in emotion regulation in daily life. The formation of implementation intention can help individuals effectively address negative emotions [13]. For example, Gallo et al. asked participants in the control, goal intention, and implementation intention groups to view the same set of bloody and disgusting pictures and rate their emotional experience [15]. The results indicated that, compared with the control and goal intention groups, only the implementation intention group successfully reduced the disgust reaction. Moreover, Gallo et al. demonstrated that when viewing a fearful (spider) picture, the emotion scores of the implementation intention group were more positive, with low levels of arousal and higher levels of sense of control, compared with those of the goal intention group [28]. Closer to the current study, there is evidence that implementation intention is an effective method for regulating anxiety. Previous studies pointed out that implementation intention could effectively regulate different forms of anxiety, including

social anxiety, generalized anxiety and anxiety about specific events [29]. Participants with high levels of social anxiety displayed a bias toward social threat words (e.g., failure). Compared with the control group, however, participants with high levels of social anxiety in the implementation intention group did not exhibit this bias in that the formation of implementation intention promoted a rapid disengagement from threatening stimuli [30]. Another clinical study used the Hospital Anxiety and Depression Scale and the State-Trait Anxiety Inventory to explore whether implementation intention could enhance self-help interventions for populations with generalized anxiety. At the baseline stage, the participants who reported anxiety symptoms were required to complete the Hospital Anxiety and Depression Scale and the State-Trait Anxiety Scale, who were randomly assigned to standard self-help, enhanced self-help, and no-intervention groups. Moreover, the participants in standard self-help group received a self-help manual that contains relaxation techniques. The participants in the enhanced self-help group received the same manual with additional materials that required them to form implementation intention and explained when and how they would use these techniques (e.g., "If I feel stressed, I will use my breathing strategy to relax!"). Lastly, the participants in the non-intervention group did not receive any intervention. After eight weeks, the participants completed the anxiety and depression measures again. The results indicated that the anxiety levels of individuals in the enhanced self-help group were lower than those of the standard self-help group and non-intervention group [31]. This finding reveals that implementation intention could be used to enhance self-help intervention for populations with generalized anxiety.

Recently, Huang et al. indicate that implementation intention is useful for the automatic regulation of aversive emotions not only in specified situation but also in goal-related unspecified situation [32]. In addition, a study that utilized event-related potential demonstrates that reappraisal-based implementation intention is not only effective in reducing immediate emotional response but also produces favorable long-term health outcomes, such as sustained late positive potential attenuation during unexpected re-exposure to observed emotional images [9]. However, the previous research focused on post hoc emotional regulation after the occurrence of an emotional event. As such, the effect of implementation intention on anticipatory emotion remains unexamined, particularly when clinically relevant individuals are involved. The current study, however, examined this issue and confirmed the effectiveness of implementation intention in regulating anticipatory anxiety regardless of the involvement of high- or low-anxiety individual. Moreover, consistent with these studies [9, 30], the current study further observed that implementation intention significantly reduced overall arousal rating for subsequent emotional pictures compared to that of the control condition irrespective of high- vs. low-anxiety or the preceding cue type. This finding further corroborates the long-lasting effects of implementation intention on the application of emotion regulation, whether the emotion is anticipatory in nature or elicited post hoc similar to previous studies. Therefore, building up implementation intention holds the potential to be broadly used in clinical intervention for affective disorders, such as generalized anxiety disorder or phobia disorder.

Acknowledgements

This study was funded by National Natural Science Foundation of China (Nos. 31871103 and 31971018).

Declaration of conflicting interests

The authors declare there are no conflicting interests regarding the content of this article.

Reference

[1] Mobini, S., Reynolds, S., Mackintosh, B. Clinical implications of cognitive bias modification for interpretative biases in social anxiety: An integrative literature review. *Cognitive Therapy and Research*, **2013**, 37(1): 173–182.

[2] Grupe, D. W., Nitschke, J. B. Uncertainty and anticipation in anxiety: An integrated neurobiological and psychological perspective. *Nature Reviews Neuroscience*, **2013**, 14(7): 488–501.

[3] Simmons, A. N., Stein, M. B., Strigo, I. A., Arce, E., Hitchcock, C., Paulus, M. P. Anxiety positive participants show altered processing in the anterior insula during anticipation of negative stimuli. *Human Brain Mapping*, **2011**, 32 (11): 1836–1846.

[4] Acheson, D. T., Stein, M. B., Paulus, M. P., Ravindran, L., Simmons, A. N., Lohr, J. B., Risbrough, V. B. Effects of anxiolytic treatment on potentiated startle during aversive image anticipation. *Human Psychopharmacology*, **2012**, 27(4): 419–427.

[5] Carlson, J. M., Greenberg, T., Rubin, D., Mujica-Parodi, L. R. Feeling anxious: anticipatory amygdala–insular response predicts the feeling of anxious anticipation. *Social Cognitive and Affective Neuroscience*, **2011**, 6(1): 74–81.

[6] Onoda, K., Okamoto, Y., Toki, S., Ueda, K., Shishida, K., Kinoshita, A., Yoshimura, S., Yamashita, H., Yamawaki, S. Anterior cingulate cortex modulates preparatory activation during certain anticipation of negative picture. *Neuropsychologia*, **2008**, 46(1): 102–110.

[7] Zhao, D. M., Li, H., Mao, J. X., Yuan, J. J. The formation of the if–then contingency in implementation intention relieves anticipatory anxiety. *Stress and Brain*, **2022**, 2(3): 78–86.

[8] Gao, W., Chen, S. D., Long, Q. S., Yang, J. M., Yuan, J. J. The progress of emotion regulation methods and paradigms: From voluntary emotion regulation to automatic emotion regulation. *Chinese Science Bulletin*, **2018**, 63: 415–424. (in Chinese)

[9] Chen, S., Yu, K., Yang, J., Yuan, J. Automatic reappraisal-based implementation intention produces early and sustainable emotion regulation effects: Event-related potential evidence. *Frontiers in Behavioral Neuroscience*, **2020**, 14: 89.

[10] Mauss, I. B., Cook, C. L., Gross, J. J. Automatic emotion regulation during anger provocation. *Journal of Experimental Social Psychology*, **2007**, 43(5): 698–711.

[11] Bargh, J. A., Gollwitzer, P. M., Lee-Chai, A., Barndollar, K., Trötschel, R. The automated will: Nonconscious activation and pursuit of behavioral goals. *Journal of Personality and Social Psychology*, **2001**, 81(6): 1014–1027.

[12] Duckworth, K. L., Bargh, J. A., Garcia, M., Chaiken, S. The automatic evaluation of novel stimuli. *Psychological Science*, **2002**, 13(6): 513–519.

[13] Sheeran, P., Aubrey, R., Kellett, S. Increasing attendance for psychotherapy: Implementation intentions and the self-regulation of attendance-related negative affect. *Journal of Consulting and Clinical Psychology*, **2007**, 75(6): 853–863.

[14] Ma, B., Meng, X. X., Long, Q. S., Zhang, Z. M., Chen, S. D., Yang, J. M., Zhang, X., Yuan, J. J. Automatic self-focused and situation-focused reappraisal of disgusting emotion by implementation intention: An ERP study. *Cognitive Neurodynamics*, **2019**, 13(6): 567–577.

[15] Gallo, I. S., Keil, A., McCulloch, K. C., Rockstroh, B., Gollwitzer, P. M. Strategic automation of emotion regulation. *Journal of Personality and Social Psychology*, **2009**, 96(1): 11–31.

[16] Gallo, I. S., McCulloch, K., & Gollwitzer, P. M. Differential effects of antecedent-and response-focused implementation intentions on the regulation of disgust. *Society for the Study of Motivation*, **2010**: 21.

[17] Azbel-Jackson, L., Butler, L. T., Ellis, J. A., van Reekum, C. M. Stay calm! Regulating emotional responses by implementation intentions: Assessing the impact on physiological and subjective arousal. *Cognition and Emotion*, **2016**, 30(6): 1107–1121.

[18] Eder, A. B. Control of impulsive emotional behaviour through implementation intentions. *Cognition and Emotion*, **2011**, 25(3): 478–489.

[19] Webb, T. L., Sheeran, P., Totterdell, P., Miles, E., Mansell, W., Baker, S. Using implementation intentions to overcome the effect of mood on risky behaviour.

The British Journal of Social Psychology, **2012**, 51(2): 330–345.

[20] *The Mental Health Scale* (Revised Edition). Wang, X. D., Wang, X. L., Ma, H. Eds. Beijing: Chinese Mental Health Journal Press, **1999**: 205–209.

[21] Li, H., Yuan, J., Lin, C. The neural mechanism underlying the female advantage in identifying negative emotions: An event-related potential study. *NeuroImage*, **2008**, 40(4): 1921–1929.

[22] Cummings, C. M., Caporino, N. E., Kendall, P. C. Comorbidity of anxiety and depression in children and adolescents: 20 years after. *Psychological Bulletin*, **2014**, 140(3): 816–845.

[23] Lang, P. J., Bradley, M. M., Cuthbert, B. N. International affective picture system (IAPS): Technical manual and affective ratings. *NIMH Center for the Study of Emotion and Attention*. **1997**, 1(39-58): 3.

[24] Bai, L., Ma, H., Huang, Y.-X., Luo, Y.-J. The development of native Chinese affective picture system-A pretest in 46 college students. *Chinese Mental Health Journal*, **2005**, 19: 719–722. (in Chinese)

[25] Nelson, E. A., Deacon, B. J., Lickel, J. J., Sy, J. T. Targeting the probability versus cost of feared outcomes in public speaking anxiety. *Behaviour Research and Therapy*, **2010**, 48(4): 282–289.

[26] Shear, M. K., Bjelland, I., Beesdo, K., Gloster, A. T., Wittchen, H. U. Supplementary dimensional assessment in anxiety disorders. *International Journal of Methods in Psychiatric Research*, **2007**, 16(Suppl 1): S52–S64.

[27] Schlund, M. W., Verduzco, G., Cataldo, M. F., Hoehn-Saric, R. Generalized anxiety modulates frontal and limbic activation in major depression. *Behavioral and Brain Functions*, **2012**, 8(1): 1–5.

[28] Gallo, I. S., Keil, A., McCulloch, K. C., Rockstroh, B., Gollwitzer, P. M. Strategic automation of emotion regulation. *Journal of personality and social psychology*, **2009**, 96(1): 11.

[29] Webb, T. L., Schweiger Gallo, I., Miles, E., Gollwitzer, P. M., Sheeran, P. Effective regulation of affect: An action control perspective on emotion regulation. *European Review of Social Psychology*, **2012**, 23(1): 143–186.

[30] Webb, T. L., Ononaiye, M. S., Sheeran, P., Reidy, J. G., Lavda, A. Using implementation intentions to overcome the effects of social anxiety on attention and appraisals of performance. *Personality & Social Psychology Bulletin*, **2010**, 36(5): 612–627.

[31] Varley, R., Webb, T. L., Sheeran, P. Making self-help more helpful: a randomized controlled trial of the impact of augmenting self-help materials with implementation intentions on promoting the effective self-management of anxiety symptoms. *Journal of Consulting & Clinical Psychology*, **2011**, 79(1): 123–128.

[32] Huang, X., Chen, S., Gao, W., Yang, J., Yuan, J. Emotion regulation by implementation intention is generalizable to unspecified situations: The nature of the underlying goal matters. *Acta Psychologica*, **2020**, 210: 103144.