Title page: Interpretation bias featured in military personnel with high trait anxiety measured by a novel paradigm

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Authors' contributions

QY contributed to the writing of this article and part of statistical analysis. DG led the whole study, including putting forward this study, getting the source and carrying out the study, and was the corresponding author. CW and ZM contributed to revising this article and part of statistical analysis. CB and SX contributed to perform the investigation and collection of all data. We are all accountable for all aspects of the work in ensuring that questions related to the

accuracy or integrity of any part of the work are appropriately investigated and resolved. We all agree to submit our research result in the article to this journal. All authors read and approved the final manuscript.

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Abstract:

Background: Anxiety has become one of the most common psychological problems affecting the combat effectiveness of soldiers. As the generation, maintenance, and recurrence of anxiety have an important interaction with interpretation bias, yet none proof was for the existence of interpretation bias in military personnel.

Methods: 112 military officers and soldiers were recruited. Based on scores of the Trait-anxiety Inventory, participants were divided into the high trait anxiety group and the low trait anxiety group. the Picture Sentence Association Paradigm comprised of

military-simulated ambiguous scenarios and emotional facial expressions was used to test the differences of the interpretation bias between the two groups.

Results: Military personnel with high trait anxiety showed interpretation bias by endorsing more negative valence to the ambiguous scenarios and reject the positive valence. Especially in a self-related scenario, the interpretation bias was more remarkable.

Conclusion: This study revealed the existed interpretation bias in military personnel with high trait anxiety using a new paradigm and highlighted the need for further researches to improve the measurement of interpretation bias. Moreover, the picture sentence association paradigm could provide plausible methods for cognitive bias modification to decrease the soldiers' anxiety.

Keywords: Anxiety; Trait anxiety; interpretation bias; military personnel; ambiguous scenario; emotion valence.

Background

Anxiety has become one of the most common psychological problems among the general population and the average level of anxiety is on the rise[1]. Unlike people living in common surroundings, Chinese military personnel is likely to undertake more stress. In the Chinese military context, military personnel is under strict military and work discipline, military training, competitions, and examinations[2]. A report,

examining data collected from 45 studies over the past two decades and evaluating changes of anxiety in Chinese military personnel from 1991 to 2011, showed both state anxiety and trait anxiety were more common in soldiers over the past two decades and the situation exacerbated[2]. In plateau troops, anxiety has even become "epidemic" in the army and coincided with physical discomfort[3]. However, the mental health of soldiers has become one of the most important criteria for evaluating the combat effectiveness of soldiers, which all the countries attach great importance to, therefore, it is imperative to deter the growing anxiety and maintain the mental well-being of the military personnel.

The relationship between Interpretation bias and anxiety

To date, cognitive theories of anxiety disorders have emphasized the critical importance of several cognitive processes in trait anxiety which is thought of as a key component related to the onset and maintaining of anxiety disorder[4, 5]. As acknowledged, cognitive processes are driven by schemata-cognitive structures associating knowledge elements that influence perception, attention, interpretation, and memory[6]. Anxious people's schemata are chronically set to easily deceive the themes of threat and danger, and consequently many situations and stimuli are associated with danger and fear[7]. Hence, when the stimuli with particularly strong fear-related associations are encountered by people having an anxiety disorder, these stimuli will attract attention quickly (attention bias), their interpretation will be biased towards danger (interpretation bias), and they will be primed in memory (memory

bias) according to the theory of cognitive bias[8, 9]. For instance, the model for social anxiety has been researched widely, which posits that individuals with elevated social anxiety tend to demonstrate negative biases in processing social cues that are indicative of negative evaluation[9]. Namely, these cues from social interaction soliciting neutral or positive emotion in normal people would be partially visualized as fear or worry for socially anxious people. In laboratory studies, the subjects are presented with a kind of vague story material or life scene (employing sentences, picture or sound or others as ambiguous stimuli) and then they are invited to make a tendentious explanation of the ambiguous situation through the self-report method (selection of different explanations, grading of different explanations, open questionnaire or interview, etc.). The results of these studies showed that anxious people were more likely to make threatening inferences than non-anxious ones who were more likely to anticipate positive outcomes[10]. Clinic researches have been focused on cognitive bias modification (CBM), based on the correction of interpretation bias of anxious people proved effective in decrease the trait anxiety level within a long-time intervention[5]. Mathews, Ridgeway, Cook, and Yiend increased CBM from a single session to four sessions and assessed trait anxiety one week later[11]. High trait anxious individuals completed a CBM program that presented ambiguous scenarios, each of which resolved in an increasingly positive manner over the four sessions, while the control group completed only a pre-assessment and post-assessment two weeks later. Results showed that the active group's interpretation was more positive and less negative than the control group at

post-assessment. More importantly, one week following the post-assessment the active group had significantly lower trait anxiety scores than the control group. Thereby, supported by laboratory studies and clinic practices, it is safe to say the generation, maintenance, and recurrence of anxiety disorder have significant interaction with interpretation bias.

Trait anxiety related to interpretation bias

In Spielberg's view, anxiety is dimerized by trait anxiety and state anxiety according to the variability and stability of anxiety[12]. Trait anxiety is a stable personality trait, while state anxiety is a temporarily emotional situation affected by the autonomic nervous system[13]. People with trait anxiety perceive the surrounding environment as a threat and induce more anxious feelings through self-evaluation and they are influenced by an individual's internal psychological stress, however, the intensity of state anxiety is not so stable and is more vulnerable to the external environment[14]. Trait anxiety can be understood as a generalization of the frequency and intensity of past state anxiety[14]. Noteworthy, Beard and Amir (2010) investigated whether interpretation bias mediated the relationship between trait social anxiety and state anxiety in response to a social evaluative threat[15]. They invited undergraduate students with high social anxiety to attend experimental sessions where students completed measures of trait social anxiety and an Interpretation Questionnaire followed by an impromptu speech and a state anxiety rating. Results revealed that participants' rankings of the negative interpretations of ambiguous social

scenarios mediated the relationship between trait social anxiety and state anxiety in response to the impromptu speech. Meanwhile, in the context of the military, a study has shown the negative cognitive bias correlated with mental health and trait anxiety of Chinese plateau military personnel, indicating the importance of the interpretation bias in the biased cognitive processing of soldiers. Hence, it is plausible to hypothesize that trait anxiety is reciprocally related to interpretation bias.

The adaptation of design for measuring interpretation bias

Most of the studies and treatment have been focused on adolescents or college students and none proof for the existence of interpretation bias in military personnel who undoubtedly experience different stress environment engendering trait anxiety and vulnerability to anxiety disorder. Therefore, it is still unfolded the relation between trait anxiety of military personnel and interpretation bias in ambiguous scenarios on the background of military environments. Furthermore, whether intervention on interpretation bias of the military personnel with high trait anxiety could be effective to guide the cognitive bias modification into military training, which aims to reduce the level of trait anxiety and improve the treatment for the anxiety disorder, is far from certain. Hence, to find whether trait anxiety would be associated with interpretation bias in ambiguous scenarios on the background of military environments and provide clinical implications for psychological help for anxious military personnel, we adopted a new method to perform this research. Referred to the previous studies, the measures of interpretation bias have been

designed primarily on the assessment of potential threat (e.g., whether the stimulus/scenario is negative, and the likelihood of a negative outcome), which repeatedly revealed that individuals with anxiety interpret ambiguous scenarios more negatively than do controls[16]. Later, Beard and Amir designed the Word Sentence Association Paradigm (WSAP) to study the role of interpretation bias in anxiety by asking subjects to complete the last word of emotional valence for a paragraph describing an ambiguous scenario[15]. Since then, WSAP becomes a typical paradigm for the following studies to measure the interpretation bias. Nonetheless, recently researches found in the process of interpreting ambiguous information the mental image would affect the mood and emotional valence[17], therefore, other paradigms also combined picture or daily experiences as the reaction choice, such as the cognitive bias modification based on imagery (CBM-I), and Picture Sentence Association Paradigm (PSAP). PSAP requires participants to identify whether the followed facial expressions (positive or negative) matched with scenarios instead of judgment to words. The facial expressions of positive or negative emotions are allowed for strong external validity and a fine-grained analysis of interpretation biases, which renders PSAP could advantage WSAP in exploring the association between trait anxiety and interpretation bias when resolving valence ambiguity of scenarios based on the intercourse of people. To ensure the validity of our research, we adopted PSAP and redesigned the scenarios on the background of military environments. Notably, the self-involvement in the scenarios was associated with the triggering of interpretation bias and effects on mental imagery [18, 19]. To distinguish self-related

and non-self-related ambiguous situations, most studies used "you" in the description of self-related scenes to increase the subject's self-involvement [16, 20], while the subject was modified to refer to a specific name of another person in non-self-related scenes. In this study, “I” was used in the self-related military-simulated ambiguous scenarios, and "company" or "comrade in arms" were used to refer to non-self-related military-simulated ambiguous scenarios, aiming to explore interpretation bias in the two different scenarios and the effect of self-involvement on interpretation.

As a special study, we invited the military personnel as our research subjects and explore the characteristics of interpretation bias to ambiguous scenarios in soldiers with trait anxiety. We hypothesized that trait anxiety is closely related to the interpretation bias of military personnel. We hope this exploration can not only enrich and improve theoretical knowledge of interpretation bias but also provide the cognitive processing model of anxious soldiers through novel experimental methods.

Methods

Participant

The convenient sampling method was used in recruitment. 112 officers and soldiers from a certain group army and a certain coastal defense brigade were selected to take the trait anxiety questionnaire. The specific population composition is shown in table 1. High social anxiety and low social anxiety groups were identified from this screening sample based on Trait-anxiety scale scores on the State-Trait Anxiety

Inventory (TAI). Individuals who scored in the top 27% (TAI total >=45) were recruited as "high trait anxiety"(5 people tied for 45 were all included in the high group), individuals who scored in the bottom 27% (TAI total <= 36) were recruited as "low trait anxiety" participants (5 people tied for 36 were all included in the low group). In this way, 34 people were enrolled in the "high trait anxiety" group; 33 people were enrolled in the low one. Research has indicated that using such analog groups based on trait anxiety measures is a viable means for studying processes present in anxious symptoms[21]. The sample was all males in the troop with an average age of 20. Groups did not differ in age, education, position, marriage, and family background. The demographic information for the two groups was presented in Table 1. In this process of performing tests, three participants in the high anxiety group were interrupted because of duty call, while four of the low anxiety group was interrupted. Thus, we eliminated the seven subjects' experimental data. The high anxiety group was consisted of 31 people, with 29 people in the low anxiety group. All subjects were male, right-handedness, with normal vision or corrected vision, and without mental illness.

Measures

Military-simulated ambiguous scenarios

According to the principle of the Delphi method, the scenarios were designed. Firstly, we collected ambiguous military scenarios by open-questionnaires, which answered by 216 military personnel. Then, the sentences were circulated to experts in the field

of military psychology who provided feedback. Next, based on experts' comments, the scenarios were revised and again assessed the ambiguity by 285 soldiers on a -5 to 5 scale (-5 was equal to the most negative meanings and 5 for the most positive meanings). Eventually, according to the recommended criterion reported by Zhu et al.[20], 81 ambiguous scenarios were selected with the emotion valence scores between 3.05-4.9 (standard error between 0.447 and 1.930), for example, “The commander told me to go to his office” appraised 4.9 points, “Before the training, the monitor said to discuss some problems with me after the dismissal” appraised 4.15, and “Commanders and instructors often disagree” appraised 3.05. The Cronbach coefficient of the questionnaire was 0.958 indicating good internal consistency. In the following study, 40 representative sentences were selected from the ambiguous scenarios, among which 20 were self-related and 20 were non-self-related. Meanwhile, the split-half reliability of the questionnaire was 0.912.

Emotional facial expression

Emotional faces were selected from the Chinese Facially Emotional Picture System (CFAPS) revised by Bai et al[22]. There were 200 negative, neutral, and positive faces, with 100 male and 100 female faces. The faces have been proved to have high reliability in emotional aspects of pleasure, arousal, dominance, and attraction, and it is a good picture material for domestic local emotion research and cross-cultural emotion comparison research. All the images in the system are black and white with a size of 6.5 cm*7.5 cm and a resolution of 102 pixels/inch.

Trait Anxiety Level

Participants completed the trait form from the State-Trait Anxiety Inventory (STAI)[13, 23], which consists of 20 items assessing symptoms of trait anxiety and has adequate psychometric properties (ranges from .73 to .86). The Cronbach coefficient of the trait-anxiety questionnaire was 0.751.

Experiment Paradigm

The experimental Paradigm was the "Picture Sentence Association Paradigm". The experiment was presented by E-Prime-2.0 software. The specific procedure was as follows: in the screen, the "+" sign was first presented to arouse the attention of the subject within 500ms, and then a military-simulated ambiguous scenario was presented within 5000ms. After the sentence disappears, an emotional face (positive or negative) would appear. If the subject thought that the positive and negative emotional valence of the face was consistent with the positive and emotional valence of the scenario, pressed the "F" key; if not, pressed the "J" key. After the key response was made, the face disappeared and the next cycle began. The positive and negative faces were counterbalanced in the 20 self-related scenarios and 20 non-self-related scenarios. The program could automatically record the reaction time and keystroke of the responses. The specific flow chart was shown in Figure 1.

Procedure

The experiment was carried out in the psychological relaxation rooms of troops (controlled as the experimental site) with a mild and suitable temperature and dimly

illuminated. Three psychologist assistants maintained the order of the site, ensured the experimental environment to be quiet, and no distraction in and out of each room where one participant was performing the computer tasks. To ensure the consent from the participants, the experimenter would inform the subjects of the anonymous experimental task was designed for investigation about their anxiety trait and further contribution to benefit the work of psychological aid for soldiers. After the informed consent was attained from the soldiers, a total task of 45 cycles was conducted, including five cycles for the practice sessions to ensure subjects familiar with the experiment before entering the experimental block. The experimental computer screen unified the black background and white character, the picture was black-white. Since it was not easy to recruit the participant again in the army, and better to reduce the disturbance to their daily training in the army, we asked the subjects to experiment directly after the questionnaire test, and only analyzed the experimental data of the selected subjects in the later stage when all of them finished the task. The resolution of the experimental computer screen was 1024*768hz. The experimental program was implemented by version 2.0 of e-prime software which would automatically record the number of positive and negative endorsement and rejection from the subjects and their response time. We converted the number of endorsement and rejection of different pictures into the form of a ratio (for example, endorsement ratio of positive faces equals the times of recognizing the positive valence face compared to the total times of positive face presented in the test), and evaluated the tendency of interpretation bias of subjects through the endorsement and rejection ratio and

response time of pictures with different emotional valence.

Statistics

The experimental data were imported into SPSS21.0 software for analysis. Test of normality by Shapiro-Wilk showed the ratios and reaction times of endorsement and rejection for the positive and negative pictures were distributed normally ($p>0.05$), which was identical with the previous researches utilizing the WSAP(Beard & Amir, 2009). Analysis of variance of repeated measurements was adopted in the design with the trait anxiety as between-subjects factors; the self-involvement type for the ambiguous scenarios and the emotional valence of faces as within-subjects factors; the ratio of endorsement as dependent factors.

Results

The interpretation differences between the high and low trait anxiety group

From the analysis of the comparison in the two groups showed in Table 1, in the responses to the ambiguous scenarios, there was no significant difference in the endorsement ratio of positive faces (calculated by the frequency of pressing the "F" button when the positive-valence face presented after the described scenarios) between the high trait anxiety group and the low trait anxiety group (F= 3.539, p= 0.065); however, as for the endorsement ratio of the negative face (calculated by the frequency of push the "F" button when the negative-valence face presented after the

described scenarios), the high trait anxiety group rated significantly higher than that of the low trait anxiety group (F=5.878, p=0.018). A significant difference between the two groups also existed in the rejection ratio, which was calculated by frequency of pressing the "J" button when the valence face presented, either for positive (F=4.488， p=0.039) or negative faces (F=4.799, p=0.033). These significances indicated that the high trait group tended to interpret the ambiguous scenarios with negative emotion valences as they showed more endorsement and lower rejection for negative faces and higher rejection of positive faces than the low anxiety group did.

As for the reaction time, one adopted concept of bias scores advocated by Bear and Amir were applied and was proved to provide a more convenient way to compare reaction time and self-report indexes. The calculated bias scores for the ambiguous scenarios were formed as below steps:

$$Negative\ bias\ score = (Rt_F - Rt_J)\ for\ negative\ face$$

$$Positive\ bias\ score = (Rt_F - Rt_J)\ for\ positive\ face.$$

Rt represents the reaction time for pressing the bottom "F" or "J". In this sense, the larger bias scores are the more tendency toward negative interpretations and away from positive interpretations. On the whole, there was a significant difference in the positive bias score between the high anxiety group and the low anxiety group (t=-2.217, p=0.031), but no significant difference in the negative bias score (t=-0.984, p=0.329) as shown in figure 2, suggesting the higher anxiety group had more tendency to reject positive interpretations and less likely to endorse them instead of

biasing negative interpretation.

The effect of self-involvement in the military-simulated ambiguous scenarios on the relation between anxiety and interpretation bias

The ANOVAs were conducted with Group (higher and lower trait anxiety) as the between-group factor and Emotional face valence (positive and negative) and Scenario type (self-related, non-self-related) as within-group factors. Meanwhile, the frequency of pressing "F" related to the scenarios by participants was calculated and deemed as the dependent variable. The attained results were presented in Table 2. Mauchly's Test of Sphericity showed Mauchly's W for the interaction was equal to 1 indicating the error covariance matrix of the orthonormallized transformed dependent variables was proportional to an identity matrix. Further analysis revealed main effects of emotional face valence, $F_{(1,58)}$=0.165, p=0.686 , and Scenario type, $F_{(1,58)}$=1.220, p=0.274, were not significant. However, the effect of Group×Emotional face valence interaction ($F_{(1,58)}$= 8.143, p=0.006), and a Group × Emotional face valence × Scenario type interaction were significant($F_{(1,58)}$=6.484, p=0.014). Therefore, exploring Group×Emotion face valence interaction by conducting analyses separately for self-related and non-self-related scenarios, we attained the effect of interaction between group and emotion face valence was significant ($F_{(1,58)}$=11.209, p=0.001) in self-related scenarios, but not in non-self-related scenarios($F_{(1,58)}$ =3.064, p=0.085). Based on the linearly independent pairwise comparisons among the estimated marginal means, the simple effect presented in Table 3 showed that, in

self-related scenarios, the high trait-anxiety group endorsed less positive faces （ $F_{(1,58)}$=5.013， p=0.029, 0.561 ± 0.045vs 0.390 ± 0.046) and negative faces ($F_{(1,58)}$=7.150, p=0.010,0.56 ± 0.045 vs 0.39 ± 0.046) than the low trait-anxiety group. Figure 3 illustrated the simple effect of emotion valence in self-related scenarios, suggesting in low trait-anxiety group the ratio for positive face endorsement was higher than that for the negative ($F_{(1,58)}$= 7.820, p= 0.007, 0.569 ± 0.041 vs 0.390 ± 0.046), while in the high trait anxiety group, the ratio for negative face endorsement was higher ($F_{(1,58)}$= 3.704， p= 0.059, 0.442 ± 0.039 vs.0.561 ± 0.045). These suggested military personnel with low trait anxiety showed positive interpretation bias while those with high trait anxiety did not possess the positive bias but also showed a tendency to endorse the negative valence of ambiguous scenarios; however, all these significances were confined in the self-related scenarios.

Discussion

This study examined interpretation bias in the military personnel with different levels of anxiety using a novel paradigm that combined military ambiguous scenarios as backdrops and emotional faces as responding stimuli. Both the analysis of responses and reaction time supported the existence of interpretation bias in military personnel with high trait anxiety. Especially, the results of responses to emotion faces, calculated by the ratios of endorsement and rejection for different emotion valence (positive and negative), were significantly different in interpretation patterns between

the high trait anxiety group and the low trait anxiety group. In line with the previous studies[24-26], military personnel with high trait anxiety endorsed more negative valence to the ambiguous scenarios and had more difficulty in rejecting the negative interpretation, besides, they were also vulnerable to rejecting the positive emotion valence for the scenarios. Notably, the study utilized the facial expressions of positive and negative emotion for strong external validity and conducted a fine-grained analysis of interpretation biases to ambiguous scenarios adapted to the military environment which facilitated our subjects' understanding and full imagery. This is a novel study to prove that the interpretation bias to the self-related scenario was remarkable in military personnel with high trait anxiety and our result is in line with previous findings that negative interpretation is closely related to anxiety[27, 28].

Prior studies have acknowledged that anxious people experience an enhanced sense of insightfulness but greater pessimism about positive events and generate fewer effective solutions to interpersonal problems and positive responses to imagined problems[29, 30]. Besides, pieces of evidence from memory tasks with thought-induction procedure proved that anxious-related disruption was found in remembering following the self-focused but not the other-focused thought induction[31]. In the non-self-related scenarios, the effect of interpretation with emotion valence was not such strong, suggesting in our cohort trait anxiety had no significant effect on understanding emotion face valence and empathizing with others. Similar studies also proved that if only emotional facial expression from other people with happy or disgust was presented to high social anxiety participants, their

sensitivity to perceiving negative evaluation did not demonstrate [32]. Moreover, if the scenarios were not related to self-interaction with other people like some ambiguous stimuli with homographs, there was no significant negative interpretation bias in the social anxiety group[7]. Therefore, we proposed that the military personnel with high trait anxiety seemed to have more self-focused thought in the interpretation of environmental stimuli and predisposed to generate the negative bias which in turn generated the state anxiety and enhanced the trait anxiety. However, as an on-line measurement, it is difficult to directly compare the current results to previous studies because the reaction times were obtained through different tasks and reflect different processes. Thus, it is not surprising that the current results differ from previous studies, as they suggest that differences in response time regarding positive and negative interpretations are important in social anxiety. However, we calculated the reaction time data with the bias score to indicate the expected interpretation bias, and we were novel to find that only bias scores for the positive face were significantly associated with an anxious level in our cohort, but the negative bias scores were not significantly different in the two groups. These explained that the anxious people's cognitive deficiency to recognize the positive cues, which was acknowledged in previous studies about social anxiety[25, 33, 34].

As a novel paradigm of combining ambiguous scenarios with positive and negative faces, procedural differences were inevitable. In terms of mixed reaction time findings, we did not present a positive or negative prime like the WASP procedure which presented a threat or benign prime followed by an ambiguous sentence. In real life,

anxious people usually do not have a prime before they encounter various stimuli. The prime activated cognitive processes involved in interpretation (e.g. negative beliefs) that then influenced the interpretation of an ambiguous sentence and the difference in reaction time data were significantly presented in the experiment[15, 35, 36]. However, in our study, the reaction data reflected the interpretation of the scenarios and the recognition of the emotion faces. Participants were allowed unlimited time to judge the relatedness of the scenarios and faces, therefore, it was difficult to demonstrate the on-line results of interpretation bias and control all the extremum in the responses. In this case, separated reaction times were not as meaningful as the compared results of bias scores. However, within the high trait anxiety group, the average reaction time also supported the negative interpretation bias as readiness to the negative faces and slow to the positive faces. It is also important to mention that using faces instead of words or other forms as response simplified the cognitive process and shorten the time for understanding, therefore, the reaction data of recognizing the face way would be closer to the real situation. Assumed that 50% represents a baseline endorsement level, the low trait anxiety group's negative endorsement was low (41%) and their positive endorsement was high (53%), while the rejection ratios were reversed for the negative (58%) and positive (47%). The high trait anxiety group's negative and positive endorsement levels (54% and 44% respectively) and rejection levels (47% and 56%) were both closer to baseline. These findings suggest that the lack of positive bias and the presence of negative bias should be conceptualized as separate constructs, which are also advised by Beard[15] and

Huppert[27]. Therefore, it may be more accurate to associate control status with a lack of a negative bias and the presence of a positive bias, rather than associating trait anxiety with bias.

The current results may have implications for clinical and military psychology. Increasing studies proofed the efficiency of cognitive treatment focused on changing interpretation bias. The core concept of the treatment is to help patients to form a positive interpretation habit and remove the negative interpretation habit through experiencing the simulated scenarios or other stimuli. Recently with the new technology emerging, the internet and mobile network facilitate the treatment and make it become an independent training instrument without the instruction of the professors, which would also be useful for military training. In our study, we attained a lot of ambiguous scenarios simulated the military environment and life events, which have been testified to be emotionally neutral. These materials could be useful in CBM-I for military personnel with high trait anxiety. Besides, the results from our study also suggested that treatments should target both negative interpretation bias and the lack of benign interpretation bias rather than target exclusively threat interpretations. People with high trait anxiety might benefit from endorsing the positive interpretation of a situation similar to they would reject the positive interpretation, especially the situation or problem with their issues. It also suggested CBM-I with the interference for self-focused thinking could be more efficient to mediate the generation of anxiety.

Limitations

Our study has several limitations that could be addressed in future research. First, the current study did not examine the specificity of the observed biases to trait anxiety rather than to depression. Although controlling for depression is common, we chose not to control it because current models of anxiety and depression suggest that these two constructs are conceptually related and co-occur for meaningful reasons. Separating them may result in spurious data[37]. Second, we used emotion faces as the provided choices for better validity and understanding, however, we found the material from CFAPS multiple emotions. Although they could be divided into two categories-positive and negative, the emotional valences of different positive emotions or different negative emotions were not specified, for instance, surprise & happiness and disgust & angry. Besides, the matching of scenarios and emotion valences was not particularly appropriate, which may affect the reaction time of the subjects. Therefore, in future studies, the paradigm should be improved by control the valence of the positive and negative emotion presented after the scenarios or ask the subjects to evaluate the degree of the endorsement or rejection of the emotional valence. Moreover, we cannot be certain that participants were reading words or ambiguous sentences. For example, participants were only responding to the faces, rather than determining the relatedness of the word to the scenarios. Finally, the coverage of military living situation was not wide enough, especially for different types of military troops and positions. These limits need to be improved in the later stage.

Conclusion

In summary, the current compared design revealed the existed interpretation bias in military personnel with high trait anxiety by the method of PSAP comprised of military-simulated ambiguous scenarios and emotional facial expressions. In the instant information-processing stage, the readiness for negative interpretation of soldiers with high trait anxiety was higher than that of soldiers with low trait anxiety, and the negative interpretation was only in self-related situations. Hence, we concluded soldiers with high trait anxiety lack the positive interpretation bias and prefer self-related negative interpretation bias. Besides, the need for further research to improve the control of emotion valences in the emotional faces used in PSAP and plausible methods of cognitive bias modification to decrease the soldiers' anxiety was highlighted.

Abbreviations

CBM: Cognitive Bias Modification; WSAP: Word Sentence Association Paradigm; CBM-I: Cognitive Bias Modification Based On Imagery; PSAP: Picture Sentence Association Paradigm; STAI: State-Trait Anxiety Inventory; CFAPS: Chinese Facially Emotional Picture System

Ethics approval and consent to participate

This study was approved by the ethics committees of the NAVY Military University.

A complete survey description was first presented to the participants. Informed written consent, together with oral approvals, was obtained before the testing session according to the Declaration of Helsinki.

Consent for publication

All the authors consented to the publication.

Availability of data and materials

The datasets analyzed and materials used in this study are available from the

the corresponding author on a reasonable request.

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

QY contributed to the writing of this article and part of statistical analysis. DG led the whole study, including putting forward this study, getting source, and carrying out the study, and was the corresponding author. CW and ZM contributed to revising this article and part of statistical analysis. CB and SX contributed to perform the investigation and collection of all data. We are all accountable for all aspects of the

work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. We all agree to submit our research result in the article to this journal. All authors read and approved the final manuscript.

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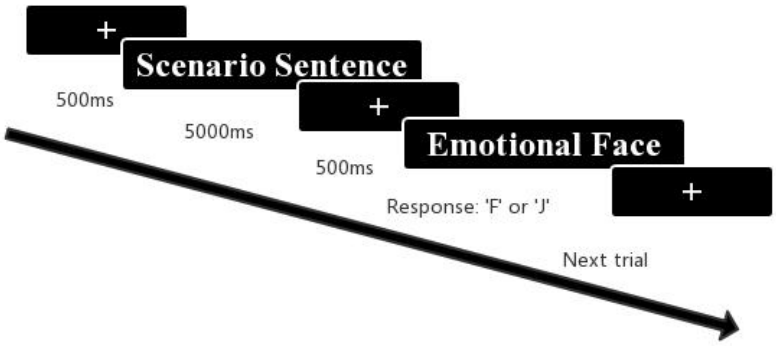
1

2 Figure 1 Flow chart for the experimental



3 paradigm

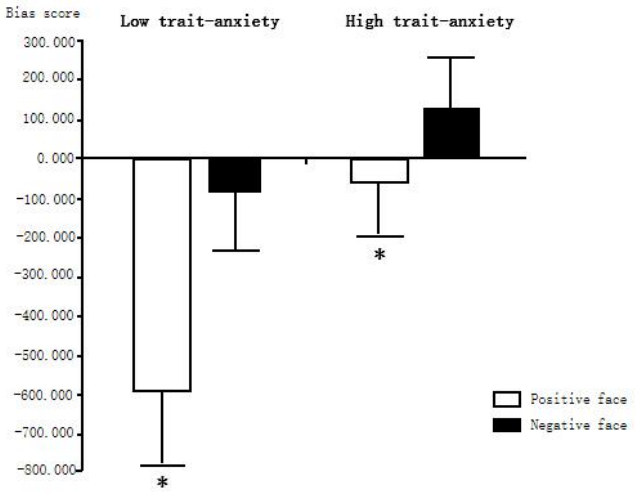
4

Table 1 Demographic information and interpretation differences in the high and low trait anxiety group.

	Trait anxiety					
	Low (n=29)	High (n=31)	Chi-square	Sig(two-tail)	F	P
Position			2.921	0.087		
Sergeant	14.5%	25.5%				
Soldier	38.2%	21.8%				
Marriage			1.749	0.353		
Married	7.4%	1.9%				
Unmarried	44.4%	46.3%				
Only-child in family			0.604	0.437		
Yes	11.1%	16.7%				
No	40.7%	31.5%				
Face endorsement ratio(M±SD)						
Positive	0.529±0.033	0.444±0.032			3.539	0.065

Negative	0.407±0.038	0.535±0.037			5.878	0.018
Face rejection ratio(M±SD)						
Positive	0.471±0.154	0.562±0.174			4.488	0.039
Negative	0.579±0.184	0.465±0.213			4.799	0.033
Face endorsement reaction time(M±SD)(s)						
Positive	1.90±0.17	2.32±0.16			3.945	0.052
Negative	2.32±0.16	2.25±0.15			0.182	0.672
Face rejection reaction time(M±SD)(s)						
Positive	2.38±1.46	2.30±0.91			0.060	0.808
Negative	2.13±0.77	2.31±0.98			0.624	0.433

Figure 2 Comparison of bias scores in high and low trait anxiety groups.



Note: Bias scores for the ambiguous scenarios: negative bias score = reaction times (reject negative face - endorse negative face) and benign bias score = reaction times (endorse positive face - reject positive face). Larger bias scores indicate more bias toward negative interpretations and away from benign interpretations.

Table 2. Analysis of variance of endorsement ratio of the emotional face in two groups based on different self-involvement ambiguous scenarios.

Source	Square Sum	df	Mean Square	*F*	*p*
Scenario type	0.033	1	0.033	1.220	0.274
Scenario type x Group	0.000	1	0.000	0.002	0.967
Emotion face valence	0.014	1	0.014	0.165	0.686
Emotion face valence x Group	0.688	1	0.688	8.143	0.006
Scenario type x Emotion face valence	0.013	1	0.013	0.793	0.377
Group x Emotion face valence x Scenario type	0.107	1	0.107	6.484	0.014
Between-group errors	3.598	58			
Within-group errors	7.403				

Table 3. The simple effect of the Group on the interaction between self-involvement and emotion face valence.

Self-involvement	Emotion face valence	Low anxiety group (Mean±SD)	High anxiety group (Mean±SD)	Mean Difference (Low-High)	Mean Difference Std.Error	F	Sig	95%CI
Self-related	Positive	0.57±0.041	0.44±0.039	.127*	0.057	5.013	0.029	0.013~0.241
	Negative	0.39±0.046	0.56±0.045	-.172*	0.064	7.150	0.01	-0.3~-0.043
Non-self-related	Positive	0.49±0.035	0.45±0.034	0.044	0.048	0.842	0.363	0.053~0.142
	Negative	0.42±0.039	0.51±0.038	-0.086	0.054	2.464	0.122	0.195~0.024

Based on estimated marginal means. The mean difference is significant at the .05 level.

Figure 3. Profile Plots for interaction between group and emotion face valence in the self-related scenarios