

RESEARCH ARTICLE

Temperament as a Moderator of Threat Interpretation Bias in Chinese Adolescents With High Test Anxiety

Shuliang Bai¹ | Lele Chen² | Peibing Liu¹ | Renlai Zhou^{1,3,4} 

¹Department of Psychology, Nanjing University, Nanjing, China | ²Department of Applied Psychology, Nantong University, Nantong, China | ³Department of Radiology, Nanjing Drum Tower Hospital, the Affiliated Hospital of Nanjing University Medical School, Nanjing, China | ⁴State Key Laboratory of Media Convergence Production Technology and Systems, Beijing, China

Correspondence: Renlai Zhou (rlzhou@nju.edu.cn)

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ABSTRACT

This study examined whether Chinese adolescents with test anxiety exhibit threat interpretation bias, and how temperament moderates in this relation. A sample of adolescents ($n = 1210$, mean = 12.27 years of age) were recruited to complete online questionnaires assessing test anxiety, threat interpretation bias, and temperament. Correlation and MANCOVA analyses assessed the relations between test anxiety, temperament, and threat interpretation, with demographic variables controlled. Results showed that compared to their low test anxiety counterparts, adolescents with high test anxiety demonstrated a significant tendency towards threat interpretation bias in both test-related and unrelated situations, accompanied by higher level of negative emotions and lower level of perceived control. Effortful control moderated the link between test anxiety and threat interpretation bias ($F = 2.24$, Wilks's $\lambda = 0.99$, partial $\eta^2 = 0.02$). These results showed that high test anxiety in adolescents is associated with threat interpretation bias, and temperament influences this relation, indicating that interventions for test anxiety should address these biases and consider individual temperament differences.

1 | Introduction

Test anxiety typically manifests as excessive worry, irrelevant thinking, mental confusion, tension, and corresponding emotional arousal when facing exams or other evaluative situations (Spielberger and Vagg 1995). In educational contexts, test anxiety differs from other forms of anxiety as it focuses on evaluative situations: individuals with test anxiety may be more inclined to perceive evaluative situations (such as finals) as threatening scenarios (Putwain and Symes 2011; Zeidner 2007), and this bias is likely to maintain and exacerbate their test anxiety when facing test-related situations.

Threat interpretation bias refers to the tendency to interpret ambiguous situations in a threatening or negative way, is

considered to be a principal component of cognitive theories of anxiety (Creswell et al. 2005; Gifford et al. 2008; Micco et al. 2013; Miers et al. 2008; Rozenman et al. 2024). For example, a late-night phone call may be seen as a wrong number (neutral interpretation) or an emergency at home (threat interpretation). Threat interpretation bias has been increasingly recognized as a cognitive mechanism that predisposes individuals to anxiety, contributes to its development, and sustains its symptoms over time (Hirsch et al. 2016; Hirsch and Mathews 2012; Creswell and O'Connor 2011). In the field of anxiety research, there is considerable evidence supporting the existence of threat interpretation bias in anxious children and adolescents (Lu et al. 2007; Stuijzand et al. 2018; Booth et al. 2024; Rozenman et al. 2024), and this interpretation bias is closely related to the severity of anxiety (Rozenman et al. 2014).

Summary

- Individuals with high test anxiety tend to interpret ambiguous situations as threatening.
- Threat interpretation bias in children with high test anxiety is not situation-specific.
- Effortful Control helps adolescents with low test anxiety reduce threat perception and negative emotions, but does not assist those with high test anxiety.

Critically, the persistence of such biases depends not only on cognitive processes but also on individual differences in self-regulatory capacity. Emerging evidence suggests that temperament traits—particularly the ability to regulate attention and emotions—may determine whether threat interpretations escalate into sustained anxiety (Raines et al. 2019). This interplay between cognitive vulnerability (threat bias) and regulatory capacity forms the conceptual foundation of our study.

Most studies have focused on threat interpretation bias in various anxiety disorders (Stuijzand et al. 2018), but its role in adolescents with test anxiety is less explored. This study aims to examine the relationship between test anxiety and threat interpretation bias by investigating three aspects: (a) the presence of threat interpretation bias in adolescents with high test anxiety (HTA), (b) whether this bias is specific to test situations or prevalent across different contexts, and (c) the impact of temperament traits, namely Effortful Control and Negative Affectivity, on the relationship between test anxiety and threat interpretation bias. The following will discuss these three questions in more detail.

1.1 | Do Adolescents With High Test Anxiety Have a Threat Interpretation Bias?

Existing research has found that individuals with HTA selectively attended to threat-related information (Hu, Oei, et al. 2023; X. Zhang et al. 2018), and showed a systematic tendency to interpret ambiguous words and sentences in a threatening manner (Calvo et al. 1997). Intrusive and repetitive worry is a core aspect of test anxiety, often leading individuals to fixate on the possibility of failure (Ehring and Watkins 2008). Such worry is closely linked to threat interpretation bias, characterized by a tendency to negatively interpret ambiguous information, thereby amplifying anxiety and repetitive negative thoughts (Hirsch and Mathews 2012). These dynamics can intensify the severity of test anxiety. In children and adolescents, it was found that compared with non-anxious children, anxious children showed stronger threat interpretation bias (Waters et al. 2008; Prieto-Fidalgo and Calvete 2024b; Yu and Wang 2024).

However, to date, only one study examined the threat interpretation bias of test anxiety. Calvo et al. (1997) found that compared to non-threatening words, individuals with HTA confirmed target words as threats faster than individuals with low test anxiety, and this interpretation bias was strategic and temporary, only occurring under self-threat related conditions.

However, there are two main limitations to the study by Calvo et al. (1997). First, the materials they used involved self-threat and physical threat, but did not include threat materials directly related to exams, so it is not possible to draw conclusions about whether individuals with test anxiety have a situation-specific threat interpretation bias (see in 1.2). Secondly, the subjects of the study by Calvo et al. (1997) were college students, whose cognitive abilities are relatively stable, while adolescence is a critical period for individual development and a risk period for the development of test anxiety. Existing research indicates that age is an important factor affecting the relationship between interpretation bias and anxiety (Waite et al. 2015). Chinese adolescents face various exams and evaluations and pressures, which is reflected in the notably high prevalence of test anxiety among middle and high school students in China, estimated at around 30% (Huang and Zhou 2019)—significantly higher than the 16.4% reported among UK secondary school students (Putwain and Daly 2014). The high value placed on educational achievement by Chinese society results in pressures and expectations that could profoundly impact adolescents' mental health. However, existing research on threat interpretation bias has predominantly focused on Western samples (e.g., Miers et al. 2008; Stuijzand et al. 2018), neglecting culturally specific factors that may shape cognitive processes in Chinese youth. Crucially, two gaps hinder culturally informed interventions: (1) Content Specificity Uncertainty: Western studies find threat bias is context-dependent (e.g., social vs. generalized anxiety; Subar et al. 2022), but in China's exam-saturated environment, threat interpretations may generalize to nonacademic situations; (2) Temperament's Contextual Role: Effortful control (EC) mitigates anxiety in low-stress Western contexts (Raines et al. 2019), yet its efficacy may diminish under China's chronic exam pressure. Therefore, investigating whether Chinese adolescents exhibit a threat interpretation bias in ambiguous contexts, and whether this bias is situation-specific, is crucial for understanding the underlying mechanisms of test anxiety and guiding the development of targeted intervention strategies within the context of China's exam-oriented education system.

1.2 | Content Specificity of Threat Interpretation Bias in Test Anxiety

Interpretation bias is usually measured and manipulated using a set of standardized questionnaire items or stimuli across multiple anxiety disorders/symptoms. For example, the Ambiguous Scenarios Task measures threat interpretation bias by presenting ambiguous short stories (written, auditory, image, or combined stimuli) to the subjects: subjects are asked to choose an ending from a list for each short story or generate their own endings, and answer a series of open-ended questions (e.g., what would you think in this situation?) and closed questions (e.g., Likert scale to assess the degree of threat in the situation; Barrett et al. 1996; Creswell et al. 2006). However, using standardized items or cross-symptom stimuli may be inconsistent with theoretical models: theoretical models suggest that the degree of threat interpretation bias may be influenced by situational content and individual anxiety type. When the content of ambiguous situations matches the subtype of anxiety (e.g., situations related to social interaction are related to social anxiety), the relationship between threat interpretation bias and

anxiety is expected to be stronger (Stuijzand et al. 2018; Hirsch et al. 2016).

Meta-analysis indicates that there is content-specific correlation between interpretation bias and anxiety symptom domains in single-sample studies (i.e., social anxiety and generalized anxiety symptoms, Subar et al. 2022). For example, Miers et al. (2008) confirmed that there is content specificity in the threat interpretation bias of adolescents with social anxiety, that is, although high-anxiety adolescents tend to have more negative interpretations of social situations compared to their non-anxious peers, this phenomenon does not exist in interpreting non-social situations. Individuals with HTA may exhibit cognitive biases in attention and interpretation, influenced by factors like stimulus relevance to exams and perceived threat levels. For example, research indicates that HTA individuals demonstrate pronounced attentional biases toward exam-related threats, with these biases not extending to non-exam-related threats (Zhang et al. 2018). Furthermore, studies have shown that while HTA can weaken the working memory capacity for words with varying relevance to exams and different levels of threat in high-pressure exam situations, in low-pressure exam contexts, only exam-related threat stimuli impair the working memory capacity of HTA individuals (X. Zhang et al. 2016). This indicates a content-specificity in the attentional biases of HTA individuals towards exam-related threat vocabularies. However, no studies have yet explored whether there is content specificity in the threat interpretation processes among HTA individuals. Understanding whether content specificity exists in the threat interpretation bias among individuals with test anxiety can enhance our understanding of the underlying causes of test anxiety and aid in the targeted selection of intervention programs. For instance, if HTA individuals primarily display interpretation biases towards exam-related threats, Cognitive Bias Modification for Interpretation (CBM-I) can be specifically tailored to address these threats, thus enhancing the efficacy of interventions in reducing test anxiety (Telman et al. 2013; Lothmann et al. 2011).

1.3 | The Role of Temperament in Test Anxiety and Threat Interpretation Bias

Temperament is defined as the early-emerging and stable patterns of emotionality, activity level, and attentional focus that lay the groundwork for the development of personality and psychological pathologies (Rothbart and Posner 2015; Rothbart and Posner 2015). Within the theoretical framework of our study, we specifically spotlight two temperament dimensions closely linked with the development of anxiety disorders: Negative Affectivity (NA) and Effortful Control (EC).

Negative Affectivity (NA) is characterized as the propensity to experience a spectrum of negative emotional states and to activate the defensive motivation system, forming a cornerstone in the nexus between temperament and anxiety. Empirical evidence underscored the association between NA and an enhanced vigilance to threat signals, manifesting in an attentional bias towards threatening stimuli (Craske 2003). For instance, studies have demonstrated that infants exhibiting

high levels of negative emotions exhibit difficulties in disengaging from fearful faces by the age of 12 months (Nakagawa and Sukigara 2012).

Effortful Control (EC), as a core regulator in the cognitive-regulation interplay, pertains to the child's capability to modulate emotions and corresponding behaviors through the deployment of attentional resources and the inhibition of behavioral responses. It indirectly mediates the intensity of children's anxiety via self-reported interpretation biases (Raines et al. 2019; Gramszlo et al. 2018). Research reveals that individuals with diminished inhibitory control are more inclined to interpret ambiguous stimuli in a threatening manner (Scheper et al. 2017), while heightened attentional focus has been associated with a diminished risk of fearful temperament precipitating anxiety symptoms in children (Gramszlo et al. 2018). Moreover, EC's linkage to test anxiety is profound. It has been found that students with elevated levels of fear yet deficient in EC exhibit an attentional bias towards threatening stimuli and face challenges in redirecting attention towards task-related stimuli (Moriya and Tanno 2007; Raymo et al. 2019). Subsequent research indicates that EC and perceived exam threats are among the most significant correlated predictors of test anxiety among individual factors (Raymo et al. 2019). This can be explained by heightened EC acting as a protective factor, enabling effective self-regulation and thus reducing anxiety symptoms in children. The interaction between NA and EC influences both the levels of anxiety and the way children focus on threats. For example, EC significantly moderated the relationship between NA and internalizing symptoms among adolescents aged 12–15 (Muris 2006), a pattern similarly observed in a cohort of children aged 9–13 (Muris et al. 2007). It is solely in children characterized by low levels of EC and elevated NA that an attentional bias towards threat stimuli becomes evident (Lonigan and Vasey 2009). Consequently, this study aims to investigate the impact of NA and EC on the relationship between levels of test anxiety and threat interpretation.

1.4 | Current Research

Integrating cognitive and regulatory perspectives, this study examines three pivotal questions: (1) does high test anxiety (HTA) lead to an increase in threat interpretations among adolescents? (2) whether threat interpretation bias in test anxiety reflects a generalized cognitive tendency beyond exam-specific contexts, and (3) how do adolescent temperament traits, specifically Negative Affectivity (NA) and Effortful Control (EC), moderate the relationship between HTA and threat interpretation?

We hypothesize that adolescents with HTA will exhibit a greater tendency to perceive threats in ambiguous situations. Furthermore, we propose that test anxiety-related threat bias is specific to test contexts, not present in unrelated situations, indicating a cognitive tendency limited to evaluative settings. Additionally, we posit that temperament will moderate the link between test anxiety and threat interpretation bias. To assess these hypotheses, we employed the

Ambiguous Situations Task, a widely recognized measure in anxiety research for children and adolescents, and developed six test-related scenarios to examine the specificity of the threat interpretation bias.

2 | Methods

2.1 | Participants

The study distributed questionnaires to middle and elementary schools in Jiangsu (Eastern China), Liaoning (Northeast China), and Guangdong (Southern China). A total of 1210 participants completed the questionnaires (Mean_{age} = 12.27, SD_{age} = 3.14; N_{male} = 652, N_{female} = 549). After dividing participants into high test anxiety (HTA) and low test anxiety (LTA) groups (see Section 2.2.3). Demographic variables are presented in Table 1.

2.2 | Measures

2.2.1 | Ambiguous Scenarios Questionnaire (ASQ; Barrett et al. 1996)

The ASQ is used to measure threat interpretation bias in children and adolescents (ages 7–14). It consists of 12 hypothetical scenarios. We revised and translated the version used by Waite et al. (2015) into Chinese. After each ambiguous scenario (e.g., “One day, you find that your favorite book is missing at school”), participants were asked to rate: (a) How they would feel in this situation (negative emotions) on a scale from 1 (*not at all upset*) to 10 (*extremely upset*); (b) How much they could do in this situation (perceived control) on a scale from 1 (*cannot do anything*) to 10 (*can do many things*); (c) Choose one of two options (threat/non-threat), for example, “Someone stole the book” (threat) or “You left the book at home” (non-threat).

TABLE 1 | Test of differences in means (standard deviations) of demographic variables, threat interpretation-related variables, perceived test threat, EC, and NA for HTA and LTA.

Characteristics	Total (N = 908)	Test anxiety		Stat test F/χ ²
		HTA (N = 345)	LTA (N = 563)	
Demographic variables				
Age	12.20 (3.21)	12.70 (3.69)	11.90 (2.83)	13.21***
Sex = female (%)	419 (46.1)	179 (51.9)	240 (42.6)	7.37*
Father's monthly income (%)				27.80***
< 2000 yuan	109 (12.0)	61 (17.7)	48 (8.5)	
2000–10,000 yuan	648 (71.4)	248 (71.9)	400 (71.0)	
≥ 10,000 yuan	151 (16.6)	36 (10.4)	115 (20.4)	
Father's years of education	11.73 (3.81)	11.12 (4.46)	12.11 (3.29)	14.58***
Mother's monthly income (%)				31.37***
< 2000 yuan	340 (37.4)	165 (47.8)	175 (31.1)	
2000–10,000 yuan	522 (57.5)	173 (50.1)	349 (62.0)	
≥ 10,000 yuan	46 (5.1)	7 (2.0)	39 (6.9)	
Mother's years of education	11.27 (3.32)	11.69 (3.19)	12.62 (3.34)	16.79***
Threat interpretation variables				
Non-test threat	0.37 (0.25)	0.52 (0.24)	0.28 (0.20)	246.8***
Non-test negative emotions	65.78 (24.24)	79.51 (21.28)	57.36 (22.01)	222.2***
Non-test perceived control	66.44 (23.72)	60.92 (22.34)	69.82 (23.93)	31.11***
Test threat	0.50 (0.26)	0.63 (0.23)	0.41 (0.25)	181.5***
Test negative emotions	34.27 (13.71)	41.08 (11.22)	30.09 (13.43)	161.7***
Test perceived control	30.89 (13.61)	27.35 (12.98)	33.05 (13.55)	39.07***
TAS	14.52 (9.24)	25.60 (3.94)	7.73 (2.58)	6804***
PTT	43.11 (8.39)	49.22 (6.99)	39.37 (6.83)	437***
EC	47.50 (7.54)	44.01 (6.38)	49.65 (7.40)	155.1***
NA	21.45 (5.60)	23.94 (5.24)	19.93 (5.25)	125.3***

Note: Differences in categorical variables were tested by chi-square test, and differences in continuous variables were tested by F test; p < 0.001***, p < 0.01**, p < 0.05*. Abbreviations: EC = Effortful control, NA = Negative affectivity, PTT = Perceived Threat of Tests questionnaire.

To examine the threat interpretation bias in exam-related scenarios, we created six scenarios related to exams (e.g., “During a Chinese exam, you forgot how to write several characters you had learned before”) and had 20 college students rate the relevance to exams (1–7) and the threat level of the threat/non-threat options (1–7) in the scenarios. The relevance and threat levels of exam-related scenarios were significantly greater than those of non-exam-related scenarios (relevance: $t = 67.57$, $p < 0.001$; threat levels: $t = 40.88$, $p < 0.001$). The inter-rater reliability (Intraclass Correlation Coefficient, ICC) for threat levels was 0.87, and for relevance, it was 0.96. The final version of the Ambiguous Scenarios Questionnaire included 18 hypothetical scenarios, comprising 12 non-exam-related scenarios and 6 exam-related scenarios. The ASQ yielded three measures: negative emotions, perceived control, and threat. The Cronbach’s alpha coefficients in this sample were 0.93, 0.94, and 0.74 (McDonald’s omega = 0.94, 0.95, 0.76), respectively.

2.2.2 | Perceived Threat of Tests Questionnaire (PTT; Cassady 2004)

The PTT was used to measure students’ perceived threat in test situations. The PTT consists of 18 items that assess students’ perceived threat of tests (e.g., “This test might have a negative impact on my grades”). We used the revised version by Raymo et al. (2019), and translated it into Chinese to reflect students’ overall feelings about tests rather than feelings about a specific test. To ensure translation fidelity, we conducted a back-translation of the Chinese version into English and verified its consistency with the original text, maintaining the validity of the measures. Items were rated on a 4-point Likert scale, ranging from “strongly disagree” to “strongly agree,” with higher scores indicating a stronger perceived threat of tests. The scale has strong internal consistency, with Cronbach’s alpha of 0.85 and 0.81 (Cassady 2004; Raymo et al. 2019), and the Cronbach’s alpha for the current sample was 0.82.

2.2.3 | Test Anxiety Scale (TAS; Sarason 1978)

The TAS consists of 37 items (0 = no, or 1 = yes), with a total score range of 0–37, and higher scores indicating higher levels of test anxiety. Following Newman’s suggestion (Newman 1996), participants with TAS scores of 20 or above were assigned to the high test anxiety (HTA) group, indicating significant discomfort in test-taking situations. Those with TAS scores of 12 or below were placed in the low test anxiety (LTA) group, reflecting minimal discomfort. The Chinese version of the TAS developed by Wang (2001) was used in this study, and its reliability and validity were satisfactory. In this study, the Cronbach’s alpha was 0.91.

2.2.4 | Early Adolescent Temperament Questionnaire-Revised (EATQ-R; Ellis and Rothbart 2001)

The EC and NA subscales of the EATQ-R were used to measure adolescents’ temperament. The Chinese version was revised by Zhang (2008), and the scale uses a 6-point Likert scale, ranging

from 1 (almost always untrue) to 6 (almost always true). The internal consistency reliability of the Chinese version of the EATQ-R was 0.71 (Zhang 2008), and the Cronbach’s alpha in this study was 0.76.

2.3 | Procedure

This study is part of a longitudinal research project. Data collection involved online questionnaires distributed through elementary and middle school teachers. Teachers sent out invitations to potential participants, who were informed about the study’s details through an introductory message attached to each questionnaire. The recruitment process ensured that participants provided informed consent before their participation, with all consents documented digitally. Participants were fully briefed on ethical considerations, including their anonymity, the voluntary nature of their participation, the procedure for withdrawing data at any point, and their right to withdraw from the study without consequences. The project received ethical approval from the Ethics Committee of the Department of Psychology at Nanjing University, and was conducted strictly according to the approved guidelines.

2.4 | Data Analytic Plan

All questionnaires were completed online, leading to no missing values. We excluded nine participants (0.7%) for excessively quick completion times (less than 5000 s), resulting in 1201 participants for the analysis. The correlation analysis focused on TAS scores and threat interpretation-related variables, including both test-related and unrelated negative emotions, along with Effortful Control (EC) and Negative Affectivity (NA).

MANCOVA was conducted on 345 high test anxiety (HTA) and 563 low test anxiety (LTA) individuals using R’s “jmv” package (<https://www.jamovi.org/jmv>). Previous research has established that test anxiety levels can be influenced by parents’ socioeconomic status (SES; OECD, P 2017), thus we included participants’ age, sex, parental education and parental monthly income as covariates. This analysis examined differences in threat interpretation between groups and the moderating effects of EC and NA on these differences.

The analytic approach comprised two parts: (1) Testing group differences and the influence of EC/NA on threat interpretation; (2) Exploring interactions between group and temperament (EC/NA) to assess how temperament traits modify the impact of test anxiety on threat interpretation.

We supplemented MANCOVA with univariate ANCOVAs for specific threat interpretation variables and conducted Johnson-Neyman tests (Johnson and Neyman 1936) via the “interaction” package in R (Long 2019) to identify conditions under which EC or NA significantly moderates the effects of test anxiety.

This streamlined analysis allows us to: (1) Determine the influence of HTA on threat interpretations in various contexts; (2) Assess whether the bias is confined to test-related

scenarios; (3) Evaluate how NA and EC modulate the HTA-threat interpretation relationship, informing targeted intervention strategies.

3 | Results

3.1 | Demographic Characteristics

The demographic and psychological profiles of HTA and LTA groups were systematically compared (Table 1). The HTA group demonstrated distinct sociodemographic characteristics, including a higher proportion of females, older age, and lower parental socioeconomic status (income and education), all $p < 0.001$. Additionally, HTA individuals exhibited heightened threat interpretation patterns (e.g., non-test threat scores: $\text{Mean}_{\text{HTA}} = 0.52$ vs. $\text{Mean}_{\text{LTA}} = 0.28$) and elevated perceived test threat ($\text{Mean}_{\text{HTA}} = 49.22$ vs. $\text{Mean}_{\text{LTA}} = 39.37$), with full statistical results detailed in Table 1.

3.2 | Threat Interpretation Bias in Test Anxiety

The results of correlation analysis showed (Figure 1) that test anxiety scores were significantly positively correlated with test-unrelated and related threats, negative emotions, PTT, and NA ($r = 0.12$ – 0.62); and significantly negatively correlated with test-unrelated and related control, EC ($r = -0.42$ to -0.22). Table 1 presents the mean scores and standard deviations of threat interpretation-related variables for HTA and LTA. Compared to

LTA, HTA had significantly higher threats and negative emotions in test-unrelated and related situations, and significantly lower perceived control in test-unrelated and related situations (all $p < 0.001$).

3.3 | The Moderating Role of EC

To test the hypothesis that EC moderates the relationship of test anxiety and threat interpretation biases, we conducted a MANCOVA controlling for age and parental SES. As detailed in Table 2, the group ($F = 75.05$, Wilks's $\lambda = 0.66$, partial $\eta^2 = 0.35$), EC ($F = 10.90$, Wilks's $\lambda = 0.93$, partial $\eta^2 = 0.05$), and the interaction of group and EC ($F = 2.24$, Wilks's $\lambda = 0.99$, partial $\eta^2 = 0.02$) significantly affected the dependent variables, that is, test-unrelated and related threats, negative emotions, and perceived control.

Univariate ANCOVAs were conducted to determine which specific dependent, parenting variable(s) contributed to the significant overall effect. The results revealing significant differences in test-unrelated and related threats, negative emotions, and perceived control among test anxiety groups; significant differences were also observed in test-unrelated threats, negative emotions, and perceived control across different levels of EC (as shown in Figure 2). Compared to LTA participants, HTA participants exhibited more threat interpretation bias, more negative emotions, and less perceived control in both test-unrelated and related situations (means and standard deviations are presented in Table 1). The interaction effect was significant for test-related threats and test-related negative emotions.

For test-related threats, the main effects of both group ($F = 194.00$, $p < 0.001$) and EC ($F = 40.36$, $p < 0.001$) were significant, and the interaction between group and EC significantly influenced the test-related threats ($F = 6.05$, $p < 0.05$). Post-hoc analyses revealed that for HTA subjects, the slope of EC predicting test-related threats was not significant ($\beta = 0.001$, $t(343) = 0.37$, $p = 0.71$, 95% CI = $[-0.0029, 0.0043]$). However, for LTA subjects, this slope was significantly negative ($\beta = -0.005$, $t(561) = -3.72$, $p < 0.001$, 95% CI = $[-0.0077, -0.0024]$). The Johnson-Neyman technique highlighted that the significant difference in the association between group and test-related threats emerged when EC was between 29.86 and 70.00, which means that within this EC range, there is no significant relationship between EC and test-related threats for the HTA group, while for the LTA group, higher levels of EC are associated with lower levels of test-related threats.

For test-related negative emotions, the main effects of both group ($F = 167.6$, $p < 0.001$) and EC ($F = 6.04$, $p < 0.05$) were significant, and the interaction between group and EC was significant ($F = 7.32$, $p < 0.01$). Post-hoc analyses revealed that for HTA subjects, the slope of EC predicting test-related negative emotions was not significant ($\beta = 0.08$, $t(343) = 0.87$, $p = 0.39$, 95% CI = $[-0.10, 0.26]$); however, for LTA subjects, the slope was significantly negative ($\beta = -0.24$, $t(561) = -3.29$, $p = 0.001$, 95% CI = $[-0.39, -0.10]$). Additionally, the Johnson-Neyman procedure identified that the simple slope of group for predicting test-related negative emotions significantly departed

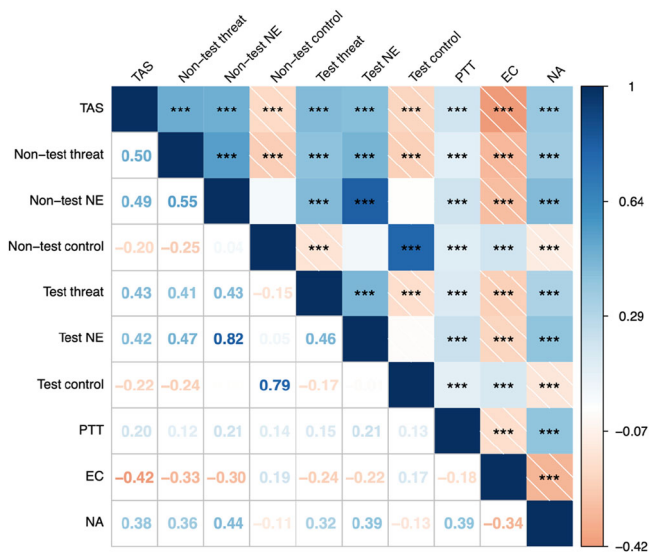


FIGURE 1 | Correlations among TAS scores, threat interpretation-related variables, perceived test threat, EC, and NA for all participants. The color bar represents the direction and strength of correlations: blue indicates positive correlations, red indicates negative correlations, and higher color saturation corresponds to larger absolute values of correlation coefficients. The upper half shows the significance of the correlation analysis, $p < 0.001$ is ***, $p < 0.01$ is **, $p < 0.05$ is *; the lower half shows the correlation coefficients; EC = effortful control, NA = negative affectivity, NE = negative emotions, PTT = perceived threat of tests questionnaire.

TABLE 2 | Predicting threat interpretation-related variables from group, EC, and the interaction of group and EC.

Independent variables	Dependent variables																					
	Post-hoc univariate ANCOVAs																					
	MANCOVA			Non-test threat			Non-test negative emotions			Non-test control			Test threat			Test negative emotions			Test control			
Wilks's λ			F	η^2	F	η^2	F	η^2	F	η^2	F	η^2	F	η^2	F	η^2	F	η^2	F	η^2	F	η^2
Group	75.05***	0.66	0.35	257.5***	0.22	232.8***	0.21	32.31***	0.03	187.3***	0.17	167.6***	0.16	39.90***	0.04							
EC	10.90***	0.93	0.05	33***	0.04	24.17***	0.03	17.71***	0.02	8.81**	0.01	6.04*	0.01	8.82**	0.01							
Group * EC	2.24*	0.99	0.02	0.97	0.00	2.82	0.00	1.47	0.00	6.54*	0.01	7.32**	0.01	2.01	0.00							
Age	0.85	0.99	0.01	2.05	0.00	0.02	0.00	0.25	0.00	0.38	0.00	0.11	0.00	0.01	0.00							
Sex	4.50***	0.97	0.03	4.35*	0.00	13.55***	0.01	5.38*	0.01	9.13**	0.01	8.34**	0.01	1.93	0.00							
Father's years of education	2.94**	0.98	0.02	2.86	0.00	7.47**	0.01	2.89	0.00	5.16*	0.01	10.97***	0.01	1.44	0.00							
Mother's years of education	2.77*	0.98	0.02	0.52	0.00	4.53*	0.01	1.11	0.00	8.12**	0.01	9.44**	0.01	2.12	0.00							
Father's monthly income	1.09	0.99	0.01	1.58	0.00	0.09	0.00	2.67	0.01	0.25	0.00	0.28	0.00	3.23*	0.01							
Mother's monthly income	1.45	0.98	0.01	1.19	0.00	0.07	0.00	5.28**	0.01	0.14	0.00	0.18	0.00	3.3*	0.01							

Note: $p < 0.05^*$; $p < 0.01^{**}$; $p < 0.001^{***}$.

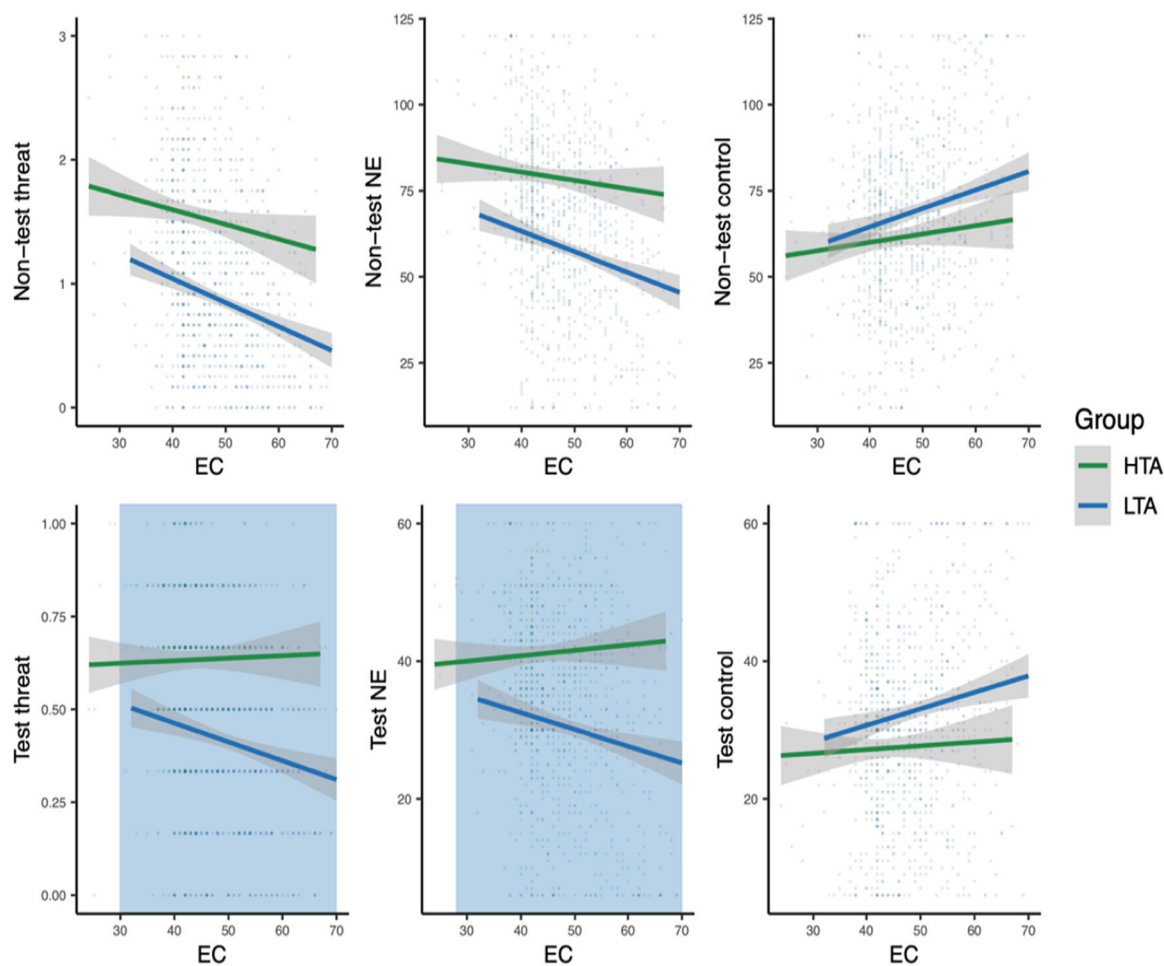


FIGURE 2 | Fitted Relationships Between EC and Predicted Variables Across Different Levels of test anxiety. *Note:* The shaded areas denote the 95% confidence intervals for each relationship. Specifically, the blue shaded areas highlight the Johnson-Neyman regions of significance, indicating intervals of EC where the simple slopes of group significantly deviate from zero ($p < 0.05$). EC = Effortful Control, NA = negative affectivity, NE = negative emotions, PTT = perceived threat of tests questionnaire.

from zero at EC levels ranging from 27.98 to 70.00, which means that within this EC range, there is no significant relationship between EC and test-related negative emotions for the HTA group, while for the LTA group, higher levels of EC are associated with lower levels of test-related negative emotions.

3.4 | The Moderating Role of NA

To test the hypothesis that NA moderates the relationship of test anxiety and threat interpretation biases, we conducted a MANCOVA controlling for age and parental SES. As detailed in Table 3, group ($F = 81.73$, Wilks's $\lambda = 0.65$, partial $\eta^2 = 0.35$), NA ($F = 25.16$, Wilks's $\lambda = 0.86$, partial $\eta^2 = 0.14$) had significant effects on the dependent variables (i.e., test-unrelated and related threats, negative emotions, and perceived control). The interaction of group and NA ($F = 1.36$, Wilks's $\lambda = 0.99$, partial $\eta^2 = 0.01$) was not significant.

The follow-up ANCOVA results revealed that there were significant differences in test-unrelated threats, negative emotions, test-related threats, negative emotions, and perceived control at different levels of NA. There were also significant differences in test-unrelated and related threats, negative emotions, and

perceived control between test anxiety groups (means and standard deviations are presented in Table 1). Significant interaction was only found in test-related threat (as shown in Figure 3).

For test-related threat, the main effects of group ($F = 194.00$, $p < 0.001$) and NA was significant ($F = 40.36$, $p < 0.001$), and the interaction between group and NA was significant ($F = 6.05$, $p < 0.05$). Post-hoc analyses revealed that for HTA subjects, the slope of NA predicting test-related threats was significantly positive ($\beta = 0.0049$, $t(343) = 2.11$, $p < 0.05$, 95% CI = [0.0003, 0.0095]). For LTA subjects, this slope was significantly more pronounced ($\beta = 0.012$, $t(561) = 6.27$, 95% CI = [0.0082, 0.0158], $p < 0.001$), indicating a stronger association between NA levels and test-related threats. The Johnson-Neyman analysis pinpointed this interaction's significance to NA levels between 34.94 and 35.00.

4 | Discussion

This study aimed to explore the relationship between test anxiety and threat interpretation bias, and the role of temperament in this context. Our findings illuminate the cognitive-regulatory

TABLE 3 | Predicting threat interpretation-related variables from group, NA, and the interaction of group and NA.

Independent variables	Dependent variables													
	MANCOVA						Post-hoc univariate ANCOVAs							
	Non-test threat		Non-test negative emotions		Non-test control		Test threat		Test negative emotions		Test control			
	F	η^2	F	η^2	F	η^2	F	η^2	F	η^2	F	η^2		
Group	81.73***	0.65	263.3***	0.23	255.9***	0.22	31.61***	0.03	194***	0.18	182.4***	0.17	39.57***	0.04
Negative affectivity	25.16***	0.86	54.76***	0.06	116.5***	0.12	2.33	0.00	40.36***	0.04	90.48***	0.09	4.32*	0.00
Group * Negative affectivity	1.36	0.99	1.20	0.00	1.63	0.00	0.99	0.00	6.05*	0.01	2.29	0.00	0.27	0.00
Age	0.85	0.99	2.11	0.00	0.02	0.00	0.24	0.00	0.39	0.00	0.12	0.00	0.01	0.00
Sex	4.04***	0.97	3.52	0.00	11.81***	0.01	4.84*	0.00	8.07**	0.01	7.32**	0.01	1.62	0.00
Father's years of education	3.84***	0.97	4.41*	0.00	10.66**	0.01	3.66	0.00	6.47*	0.01	13.71***	0.02	1.88	0.00
Mother's years of education	2.68*	0.98	0.39	0.00	4.06*	0.00	1.17	0.00	7.67**	0.01	8.82**	0.01	2.09	0.00
Father's monthly income	1.54	0.99	0.99	0.01	0.63	0.00	4.7*	0.02	1.2	0.01	0	0.01	3.64	0.02
Mother's monthly income	1.48	0.99	1.32	0.01	0.01	0.00	4.44*	0.02	0.33	0.01	1.12	0.01	5.68*	0.01

Note: $p < 0.05^*$; $p < 0.01^{**}$; $p < 0.001^*$.

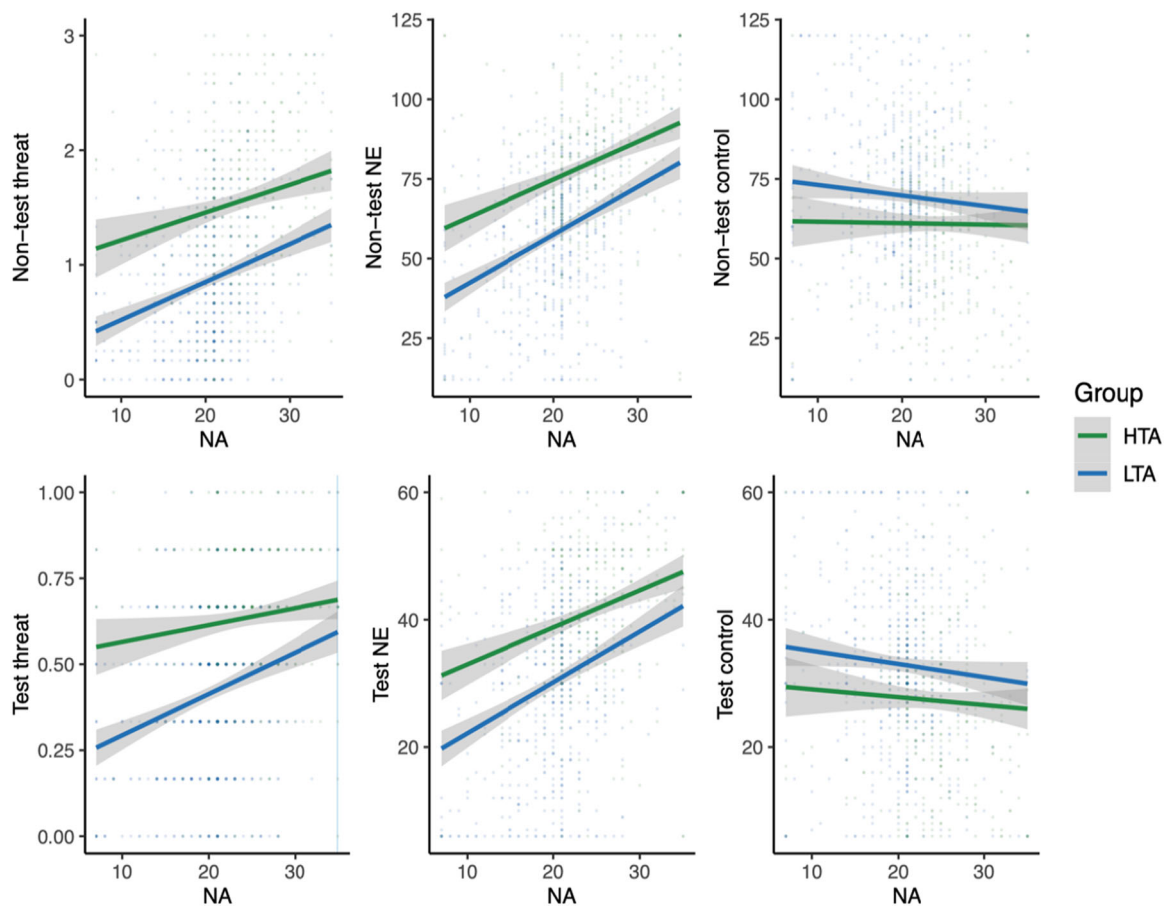


FIGURE 3 | Fitted Relationships Between NA and Predicted Variables Across Different Levels of test anxiety. *Note:* The shaded areas denote the 95% confidence intervals for each relationship. Specifically, the blue shaded areas highlight the Johnson-Neyman regions of significance, indicating intervals of NA where the simple slopes of group significantly deviate from zero ($p < 0.05$). EC = effortful control, NA = negative affectivity, NE = negative emotions, PTT = perceived threat of tests questionnaire.

dynamics of test anxiety. While threat interpretation bias generalized across contexts, effortful control's moderating role was context-dependent—effective in low-stress scenarios but attenuated in test-related contexts. This suggests that chronic environmental pressure may exhaust regulatory resources, a phenomenon requiring integration into future cognitive models of anxiety.

In line with the findings of Cassady (2004) and Raymo et al. (2019), our correlation analysis revealed a positive association between the severity of test anxiety in adolescents and their perception of test-related threats. Results of Ambiguous Scenarios Questionnaire also align with research on various anxiety subtypes (Alkozei et al. 2014; Carthy et al. 2010; Creswell and O'Connor 2011; In-Albon et al. 2008, 2009; Miers et al. 2008), showing that HTA adolescents are more likely to view ambiguous situations as threatening, experience more negative emotions, and feel less control, compared to their low-test anxious (LTA) peers. In this study, we constructed six ambiguous scenarios related to testing and confirmed their reliability and validity to test whether the threat interpretation bias in test-anxious individuals exhibits content specificity. The results showed that compared to LTA, HTA tends to interpret both test-unrelated and related situations as threats, also shows more expected negative emotions, and less perceived control. This finding is consistent with the results of a meta-analysis: there is

a larger association between interpretation bias and anxiety when the content of the content matches the subtype of anxiety, but the association still exists when it does not match (Subar et al. 2022). This indicates that Cognitive Bias Modification for Interpretation (CBM-I) is an effective intervention for test anxiety (de Hullu et al. 2017; Krebs et al. 2018; Lau 2013; Martinelli et al. 2022; Saleminck and Wiers 2011), by increasing the positive automatic associations related to threat (Sportel et al. 2013) regardless of whether they are content-specific to the subtype of anxiety.

Our study explored how temperament traits such as Effortful Control (EC) and Negative Affectivity (NA) affect the relationship between test anxiety and threat interpretation bias. We discovered that low test-anxious adolescents exhibit significantly higher levels of EC compared to their high test-anxious counterparts. Adolescents with high EC levels demonstrate greater control, less threat interpretation, and fewer negative emotions in both test-related and unrelated situations. This is consistent with findings by Raymo et al. (2019), who reported a significant negative correlation between EC and test anxiety scores, indicating that higher EC is associated with lower perception of test threat. Similarly, Raines et al. (2019) found that EC is negatively correlated with children's anxiety levels and their self-reported interpretation bias. Our findings also reveal that EC significantly moderates the relationship between test

anxiety groups and test-related negative emotions. Consistent with test-related interpretations bias, as EC increases, negative emotions decrease among LTA individuals. This aligns with prior research suggesting that individuals with better inhibition are more capable of suppressing negative emotions (Bridgett et al. 2013; von Hippel and Gonsalkorale 2005). However, we found that for HTA individuals, negative emotions remain unaffected by levels of EC, which may be explained by the possibility that elevated test anxiety impairs the regulatory function of EC on negative emotions (Raymo et al. 2019). These studies collectively affirm that developing EC can serve as a protective factor against test anxiety, enabling adolescents to respond more adaptively to environmental stimuli, thereby mitigating the risk of anxiety.

Our research highlights that EC moderates the impact of test anxiety on threat interpretation, but its effects vary between LTA and HTA adolescents. LTA adolescents with higher EC levels show reduced perception of threat and fewer negative emotions in ambiguous situations. However, HTA adolescents consistently interpret situations as threatening regardless of their EC levels, particularly in test-related contexts. In contrast, in non-test situations, high EC can reduce threat perception and negative emotions even among HTA adolescents. This suggests that high test anxiety predisposes adolescents to interpret test-related situations as more threatening, a bias resistant to the moderating influence of EC. This observation supports the cognitive-attentional model, indicating that high test anxiety can disrupt cognitive functions by fostering negative thoughts and impairments in working memory during tests (X. Zhang et al. 2016; Hu, Song, et al. 2023; Song et al. 2021).

The Johnson-Neyman analysis indicated that significant differences in test-related threat perception between high-test anxious (HTA) and low-test anxious (LTA) groups emerged only when negative affectivity (NA) reached extreme levels (outside the [34.94, 139.37] interval). However, the NA in the study did not exceed 35.00, suggesting that individuals in the LTA group are more sensitive to test-related threats at higher NA levels, potentially due to a saturation effect in HTA individuals where further increases in NA minimally affect threat perception. These results underscore the importance of developing targeted preventative strategies for individuals in the LTA group who exhibit higher NA. The objective of such strategies should be to specifically reduce threat perception, thereby preventing the escalation of test anxiety. This approach is critical because individuals with higher level of NA have difficulties disengaging from threats (Nakagawa and Sukigara 2012), which may exacerbate anxiety during assessments.

5 | Limitations and Directions for Future Research

This study has several limitations. Firstly, its cross-sectional design does not allow for causal inferences between test anxiety and threat interpretation bias. Prior longitudinal research (e.g., Prieto-Fidalgo and Calvete 2024a) has identified bidirectional effects between social anxiety and interpretation bias, suggesting a dynamic feedback loop in which each reinforces the other. This reciprocal mechanism may also apply to test anxiety

(Würtz and Sanchez-Lopez 2023). Therefore, future studies should employ longitudinal designs, such as cross-lagged panel models, to better characterize the temporal interplay between interpretation bias and anxiety severity. Secondly, our use of self-reported offline tasks, which allow participants time to reflect, may not capture the more automatic components of cognitive bias. Future research should incorporate online paradigms that assess interpretation tendencies under time pressure, enabling researchers to probe the early, automatic stages of threat interpretation (Feng et al. 2019; Moser et al. 2008, 2012).

Importantly, the current findings also have potential clinical implications. The Johnson-Neyman analysis identified a neuroticism threshold ($NA \geq 34.94$) at which LTA individuals begin to exhibit threat perception levels comparable to those of the HTA group. This suggests that individuals with subclinical levels of test anxiety but elevated neuroticism may already be at risk of cognitive distortions and could benefit from early intervention. Preventive efforts might focus on reducing neurotic tendencies—such as through mindfulness-based stress reduction or cognitive restructuring—to buffer against the development of maladaptive interpretation patterns. In contrast, HTA adolescents showed limited benefit from emotion control (EC) in test-related contexts, highlighting the need for more context-sensitive strategies. For this group, targeted interventions may include immersive training—such as virtual reality simulations of test situations—paired with EC skill enhancement to improve transfer and effectiveness under real evaluative stress. Collectively, these findings underscore the importance of tailoring cognitive interventions to both anxiety severity and personality profiles, and they support a move toward more personalized approaches to anxiety prevention and management in educational settings.

6 | Conclusion

This study has demonstrated that adolescents with high test anxiety (HTA) exhibit a marked bias towards interpreting ambiguous stimuli as threats, not only in test-related situations but across various contexts. This tendency is associated with higher level of negative emotions and lower level of sense of control, underscoring the pervasive impact of test anxiety on adolescents' psychological experiences. Our findings also highlight the crucial role of temperament in moderating the relationship between test anxiety and threat interpretation bias. Individuals' temperamental characteristics influence the extent to which anxiety translates into cognitive biases, suggesting that interventions might be tailored according to temperament profiles to mitigate the negative effects of test anxiety.

Author Contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Shuliang Bai. The first draft of the manuscript was written by Shuliang Bai and Lele Chen, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Ethics Statement

The study was approved by the Ethics Committee of the Department of Psychology at Nanjing University and conducted according to the approved guidelines.

Consent

All participants provided informed consent before participation in the study.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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