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The relationship between trait anger and reactive aggressive behavior in middle school students: the mediating role and intervention of hostile attribution bias

Shuang Lin[1,2,3], Xuejun Bai[2], Gonglu Cheng[2] and Wen Liu[3*]

Abstract

Background The reactive aggressive behavior in individuals typically shows a rapid growth trend as individuals enter adolescence, and peaks during middle-school period. According to the Comprehensive Cognitive Model of Trait Anger, trait anger and hostile attribution bias play important roles in the development of reactive aggressive behavior. Based on this, current study explored the relationship between trait anger and reactive aggressive behavior in middle school students, as well as the mediating role of hostile attribution bias and interventions.

Methods The current study consisted of three sub-studies. Study 1 recruited 87 middle school students with an average age of 12.367 ± 0.889 years, investigated the relationship between trait anger and reactive aggressive behavior, as well as the mediating role of trait hostile attribution bias. Study 2 recruited 62 middle school students with an average age of 13.376 ± 0.963 years, investigated the relationship between trait anger and reactive aggressive behavior, as well as the mediating role of state hostile attribution bias. Study 3 recruited 80 middle school students with an average age of 13.392 ± 0.977 years, implemented an intervention targeting trait hostile attribution bias in middle school students with high trait anger to reduce their reactive aggressive behavior. In current study, data management was performed using SPSS 22.0. Descriptive statistics, independent samples *t*-test, paired samples *t*-test, repeated measures analysis of variance (ANOVA), and path analysis were used for statistical analysis.

Findings The results of Study 1 showed that trait anger predicted reactive aggressive behavior through trait hostile attribution bias. The results of Study 2 indicated that trait and state hostile attribution bias played mediating role intermediary, and trait hostile attribution bias had a stronger mediating effect than state hostile attribution bias. The results of Study 3 suggested that the intervention effectively decreased trait hostile attribution bias and reactive aggressive behavior.

Conclusions Trait anger can predict the reactive aggressive behavior of junior high school students, with trait hostility attribution bias and state hostility attribution bias mediating this relationship. Intervening in the hostility attribution bias of high-anger junior high school students can effectively reduce their reactive aggressive behavior.

*Correspondence:
Wen Liu
wenliu703@126.com

Full list of author information is available at the end of the article

Keywords Trait anger, Trait hostile attribution bias, State hostile attribution bias, Reactive aggressive behavior, Mediating, Intervention

Introduction

Reactive aggressive behavior refers to behavioral responses towards threatening or frustrating events that are driven by external hostile environments [1]. Such behavior is commonly observed in daily life, such as yelling at others when provoked, throwing tantrums when frustrated, engaging in conflicts with others due to teasing, or getting into physical fights to protect oneself when threatened. A localized study in China found that among 9,958 Chinese school-age children and adolescents, the prevalence of proactive aggressive behavior was 2.6%, reactive aggressive behavior was 11.2%, and the co-occurrence of both was 5.9% [2]. Reactive aggressive behavior in adolescents serves as a predictor for severe violent and criminal behaviors in adulthood [3]. It can significantly impair social functioning, quality of life, psychological well-being, and physical health for both perpetrators and victims, and even cause substantial economic losses to society. Previous research has found that reactive aggressive behavior emerged as early as around the age of 4 in children, and it increased as individuals enter adolescence, with a peak in reactive aggressive behavior during the middle school stage [4]. Therefore, it was necessary to explore the risk factors of reactive aggressive behavior and sought methods or pathways for prevention to reduce its adverse effects.

Previous research has shown that trait anger was an important personality factor for reactive aggressive behavior [5], while hostile attribution bias was an important cognitive factor [6]. Trait anger refers to an internal, stable, and context-independent tendency toward anger, which is a persistent and stable personality trait in terms of the frequency, duration, and intensity of anger [7]. Hostile attribution bias refers to the tendency of individuals to interpret ambiguous social information or hostile information (such as sounds, words, pictures, facial expressions, behaviors, etc.) in a hostile manner [8]. Hostile attribution bias can be divided into two levels: trait and state, from a dynamic and static perspective. Trait hostile attribution bias refers to the stable cognitive tendency of individuals to interpret various social information from a hostile perspective, while state hostile attribution bias refers to the cognitive response of individuals to specific stimuli or situations that are interpreted from a hostile perspective [5].

The General Aggression Model and the Integrated Cognitive Model have explored the relationship between trait anger, hostile attribution bias, and reactive aggressive behavior, but different theories had different perspectives on this issue. The General Aggression Model emphasized the single risk role and cumulative risk role of individual factors, situational factors, and internal cognitive states in the informational process of reactive aggressive behavior [9]. Trait anger belonged to individual factors, while hostile attribution bias belonged to the individual's internal cognitive state, but this theory did not clearly explain the relationship between trait anger, hostile attribution bias, and reactive aggressive behavior. On the other hand, the Integrated Cognitive Model further clarified the pathway through which trait anger influenced individual reactive aggressive behavior through hostile attribution bias [10, 11]. Specifically, high trait anger made individuals more prone to interpret situations in a hostile manner, which in turn triggered their hostile attribution bias and ultimately led to reactive aggressive behavior. However, it was not clear whether the hostile attribution was an individual's trait or a cognitive state influenced by the situation.

The relationship between trait anger, hostile attribution bias, and reactive aggressive behavior has been explored in previous research, but most of the studies have been based on cross-sectional questionnaire data and have focused on trait hostile attribution bias, lacking exploration from the perspective of state hostile attribution bias. Kolla et al. (2017) conducted a study with 47 individuals with antisocial personality disorder (ASPD) and borderline personality disorder (BPD), and the results showed that both trait anger and hostile attribution significantly positively predicted aggressive behavior in individuals with ASPD and BPD [12]. For these individuals, high trait anger and high hostile attribution were associated with higher levels of aggressive behavior and even violent behavior. Additionally, in the field of behavioral genetics, Gustavsson et al. (1996) used behavioral genetics methods to examine the sources of individual differences in trait anger, hostility, and anger-related aggressive behavior [13]. The study included 26 identical twins and 16 fraternal twins, and the results showed that environmental factors accounted for the similarity in hostility between siblings, while genetic factors explained the similarity in trait anger and anger-related aggressive behavior. Therefore, this study proposed the hypothesis that there was a significant positive correlation between trait anger and reactive aggressive behavior (Hypothesis 1), and trait hostile attribution bias and state hostile attribution bias mediated this relationship (Hypothesis 2).

In addition, although there was a lack of direct evidence in research to change the hostile attribution bias of individuals with high trait anger and reduce their reactive aggressive behavior, studies have found that it was possible to achieve a certain degree of reduction in individual

reactive aggressive behavior by intervening in their hostile attribution bias. For example, Van Bockstaele et al. (2020) conducted hostile attribution bias modification training with individuals who exhibited high aggressive behavior, effectively reducing their levels of hostile attribution bias and reactive aggressive behavior [14]. Additionally, Hiemstra et al. (2019) effectively reduced the hostile interpretation of ambiguous facial expressions in boys with aggressive behavior problems using cognitive bias modification techniques [15]. Specifically, in this study, participants were shown 15 photos of boys (including 5 happy pictures, 5 angry pictures, and 5 emotionally ambiguous pictures), and when the participants identified the emotionally ambiguous pictures as happy or angry, they were given feedback: "Correct/Incorrect, this face is happy/angry." The training was conducted continuously for 5 days, and the results showed that the participants' hostile attribution bias was effectively improved, but their aggressive behavior was not significantly reduced.

To summarize, the General Aggression Model highlighted the cumulative risk role of trait anger and hostile attribution bias in reactive aggressive behavior, while the Integrated Cognitive Model suggested that trait anger affects reactive aggressive behavior through its influence on hostile attribution bias. However, both models did not explicitly address the role of trait and state hostile attribution bias in the relationship between trait anger and reactive aggressive behavior. In terms of the lifelong development of reactive aggressive behavior, it generally showed an initial increase followed by a decline, reaching its peak in middle school [4]. Therefore, this study focused on middle school students and investigated the relationship between trait anger and reactive aggressive behavior, as well as the mediating role of hostile attribution bias through three studies. Study 1 examined the relationship between trait anger and reactive aggressive behavior in middle school students, as well as the mediating role of trait hostile attribution bias. Study 2 investigated the relationship between trait anger and reactive aggressive behavior in middle school students by activating state hostile attribution bias, as well as the chain mediating role of trait hostile attribution bias and state hostile attribution bias. Study 3 aimed to reduce reactive aggressive behavior by intervening in the hostile attribution bias of middle school students with high trait anger.

Study 1 The Relationship between trait anger and reactive aggressive behavior in middle school students: The mediating role of trait hostile attribution bias.

Method

Participants

We estimated the required sample size using G*Power 3.1. Study 1, employed a linear multiple regression of 2 predictors, with $f=0.15$, $\alpha=0.05$, and a statistical power of 0.8; the estimated sample size was 68. This study recruited 100 middle school students from two middle schools in a certain city to participate in the study. However, 2 participants dropped out of the study due to the lengthy duration of the testing, and another 11 participants reported randomly pressing keys to expedite the experiment. After excluding these individuals, a total of 87 participants (48 males, 39 females) with an average age of 12.367 ± 0.889 years were included in the final sample. The age range of the participants was between 12 and 16 years old, encompassing grades 7 to 9. Following the methods of Guo & Xia (2023) and Wang et al. (2023), differences in trait anger scores and trait hostility attribution bias between invalid and valid participants were examined [16, 17]. The results indicated that there were no significant differences between invalid and valid participants in trait anger ($t(98) = -1.276$, $p=0.205$) and trait hostility attribution bias scores ($t(98) = -0.441$, $p=0.66$). The results suggested that invalid and valid participants were homogeneous, and excluding invalid participants did not affect the robustness of the research findings. Based on the results of the school's mental health screening, the participants in this study had normal intelligence and did not have conduct disorders or mental disorders. This study obtained approval from the Ethics Committee of Tianjin Normal University and informed consent was obtained from all participants. Participants were also provided with compensation after the completion of the experiment.

Measures

Trait anger This study measured individuals' trait anger using the Trait Anger subscale from the State-Trait Anger Expression Inventory (STAXI) developed by Spielberger (1995) [7]. The scale was revised by Chinese scholars, including Luo et al. (2011), based on a sample of Chinese adolescents [18]. The Trait Anger subscale consisted of 10 items, with two factors: Trait Temper Anger and Trait Reactive Anger. Participants rated each item using a 4-point Likert scale (1=Never, 4=Always). Higher scores indicated higher levels of trait anger. The Cronbach's α coefficient for this scale in the study was 0.886.

Trait hostile attribution bias The WSAP-Hostility scale has been widely used to assess individuals' trait hostility attribution bias [19]. Accordingly, in current study, the Chinese version of the scale was used, specifically the Hostility Attribution subscale, to measure individuals' trait hostility attribution bias. This subscale has been shown

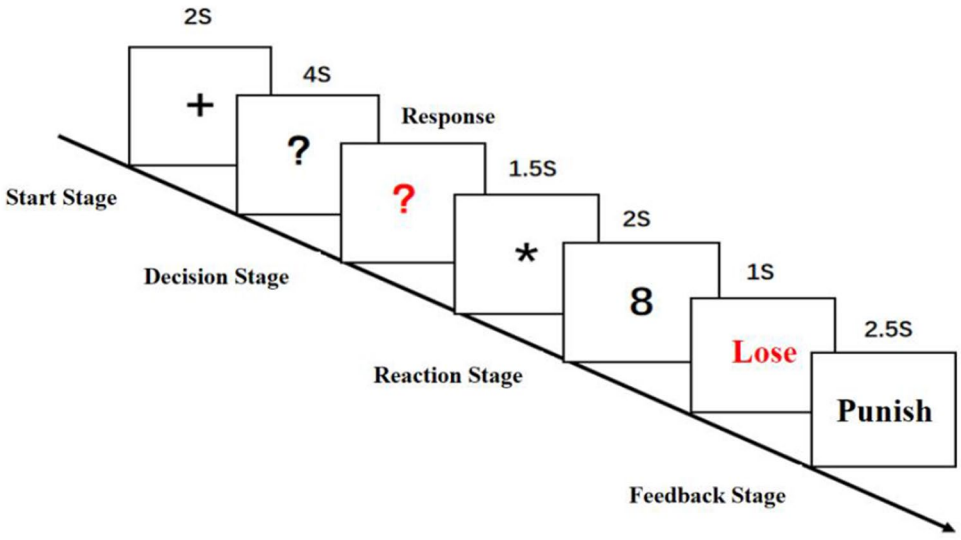

Fig. 1 Experimental procedure flowchart

good reliability, validity, and cross-cultural consistency [6]. In this subscale, participants were required to rate the relevance of hostility-related adjectives to ambiguous situations after reading 16 sentences of varying provocation levels. Participants rated the relevance of these words and sentences on a 6-point Likert scale (1 = Not at all relevant; 6 = Very relevant) based on their own understanding of the context. The Cronbach's α coefficient for this scale in our study was 0.815.

Materials and procedure

In the competitive reaction time paradigm, participants engaged in a button-pressing competition with virtual players. Specifically, participants were required to make a button response as quickly as possible when they saw a specific signal. The winner of the competition was allowed to administer a punishment (e.g., noise or electric shock) to the loser. However, the game results, the order of wins and losses, and the predetermined level of punishment chosen by the virtual players were set by the experimenter in advance. The punishment level chosen by the participants was considered as a measure of aggressive behavior [20]. In this study, the noise level chosen by the participants in advance was used as a measure of reactive aggressive behavior, ranging from 1 to 9 [21–23]. This paradigm and its variations have been applied in previous research to measure reactive aggressive behavior in different age groups, including children [24], adolescents [25], and adults [26].

The study consisted of four stages.

Stage 1: Start stage. The computer screen initially displayed opponent information and prompted the participant to prepare for the experiment.

Table 1 Correlation between variables ($N = 87$)

Variables	*M*	*SD*	1	2	3
Trait Anger	1.864	0.619	1		
Trait Hostile Attribution Bias	3.073	1.147	0.341**	1	
Reactive Aggressive Behavior	6.451	2.075	0.603***	0.243*	1

Note $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Stage 2: Decision stage. The computer screen presented a black question mark, and the participant needed to think about the level of punishment they would administer to the opponent if they won the competition. When a red question mark appeared, the participant needed to select the punishment level for the opponent (ranging from 1 as the lowest level to 9 as the highest level).

Stage 3: Reaction stage. When a black asterisk appeared on the computer screen, the participant needed to make a quick button response to win the competition.

Stage 4: Feedback stage. The outcome of the competition was presented on the computer screen, but the probability of winning or losing was predetermined by the experimenter. If the participant won the competition, the opponent received a noise punishment; otherwise, the participant received the punishment. The specific task flow was illustrated in Fig. 1.

Results

Relation analysis

After controlling for gender and age, the specific results of the partial correlation were shown in Table 1.

Mediating analysis

This study used the PROCESS plugin in SPSS to conduct a simple mediation analysis. Gender and age were

included as covariates. The results of the mediation model were as follows in Table 2; Fig. 2.

In addition, age had a non-significant predictive effect on hostile attribution bias (β = -0.011, p=0.939) and reactive aggressive behavior (β = -0.147, p=0.266). Gender had a non-significant predictive effect on hostile attribution bias (β = -0.172, p=0.408), but a significant predictive effect on reactive aggressive behavior (β = -0.449, p=0.025).

The results showed that, in the relationship between trait anger and reactive aggressive behavior, the partial mediating effect of trait hostile attribution bias was significant (95% CI = [0.017, 0.195] did not include 0), and the indirect effect accounted for 28.43% of the total effect. The specific details were shown in Table 3.

Table 2 The paths analysis of trait hostile attribution bias (N=87)

Paths	Estimate	*p*	95% CI	
			Low-CI	High-CI
TA-RAB	0.236	0.025	0.030	0.442
TA-THAB	0.340	0.001	0.136	0.545
THAB-RAB	0.238	0.025	0.031	0.445

Note TA=Trait Anger, THAB=Trait Hostile Attribution Bias, RAB=Reactive Aggressive Behavior

Table 3 The mediating analysis of trait hostile attribution bias (N=87)

Effects	Estimate	95% CI		%
		Low-CI	High-CI	
Direct Effect	0.236	0.030	0.442	74.448%
Indirect Effect	0.081	0.012	0.177	25.552%
Total Effect	0.317	0.118	0.515	

Discussion

This study first examined the relationships between trait anger, trait hostile attribution bias, and reactive aggressive behavior in middle school students. As expected, all the study variables were found to be significantly positively correlated. Secondly, we tested the mediating role of trait hostile attribution bias in the relationship between trait anger and reactive aggressive behavior. The results revealed a significant mediating effect of trait hostile attribution bias.

These findings partially supported the Integrated Cognitive Model [10, 11] and were consistent with previous research. For example, Bondü and Richter (2016) also examined the relationship between trait anger, trait hostile attribution bias, and aggressive behavior [27]. The results showed that trait anger and trait hostile attribution bias were stable risk factors for various types of aggressive behavior (reactive/proactive aggression, physical/verbal/relational aggression) in adults. Sorella et al. (2022) used machine learning methods to examine the relationship between neural network structures and trait anger in 71 adults [28]. The results showed that the gray matter concentration in the intra-insular cortex, posterior cingulate cortex, and fusiform gyrus were related to levels of trait anger. Moreover, individuals with more focused attention and a tendency to shift their attention towards hostile events were more likely to experience anger in their daily lives and to interpret these events with higher levels of hostility, potentially leading to higher levels of aggressive behavior.

Study 2 The Relationship between trait anger and reactive aggressive behavior in middle school students: The mediating role of state hostile attribution bias.

The results of Study 1 indicated that trait anger significantly predicted reactive aggressive behavior, and trait hostile attribution bias served as a mediator in this relationship. Study 2 further investigated the role of state hostile attribution bias in the association between trait anger and reactive aggressive behavior by incorporating a hostile attribution manipulation procedure into the competitive reaction time paradigm.

Methods

Participants

Recruitment was conducted to gather 900 middle school students (479 males and 421 females) from two middle schools in a certain city. The students were in grades 7 to 9 (equivalent to first to third year of middle school). They were invited to complete the Trait Anger scale of the State-Trait Anger Expression Inventory as part of a screening process for a behavioral experiment. The collected data was then used to classify the students into high and low trait anger groups. The top 30% of scores were categorized as the high trait anger group, while the

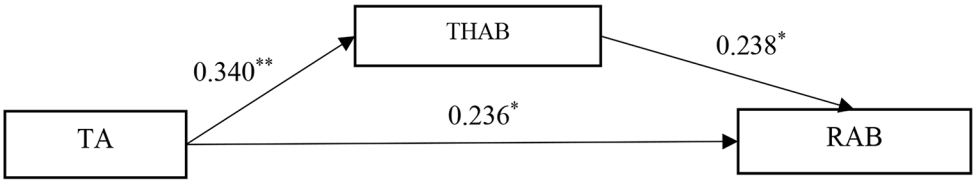

Fig. 2 The model of mediating role of trait hostile attribution bias. TA = Trait Anger, THAB = Trait Hostile Attribution Bias, RAB = Reactive Aggressive Behavior. $^{*}p<0.05$, $^{**}p<0.01$

bottom 30% were categorized as the low trait anger group. We estimated the required sample size using G*Power 3.1. Study 2, employed a 2×2 mixed design, with $f=0.25$, $\alpha=0.05$, and a statistical power of 0.8; the estimated sample size was 66. From high trait anger group and low trait anger group, 70 students were recruited to participate in the study 2. However, during the experiment, 3 participants dropped out due to the lengthy duration of the test, and 5 participants mentioned in the post-experiment interview that they randomly pressed buttons in order to finish the experiment quickly. Ultimately, data from 62 participants were considered valid for analysis, with 27 participants in the high trait anger group and 35 participants in the low trait anger group. The average age of the participants was 13.376±0.963 years, ranging from 12 to 15 years, covering grades 7 to 9. Differences in trait anger, trait hostility attribution bias, and state hostility attribution bias scores between missing and valid participants were examined. The results showed that there were no significant differences between missing and valid participants in trait anger ($t(68)=0.021$, $p=0.983$), trait hostility attribution bias scores ($t(68)=1.128$, $p=0.263$), and state hostility attribution bias ($t(68) = -0.81$, $p=0.421$). The results suggested that missing and valid participants were homogeneous, and excluding missing participants did not affect the robustness of the research findings.

Based on the results of the school's psychological health screening, all participants in this study were found to have normal intelligence and no conduct or mental disorders. The study was approved by the Ethics Committee of Tianjin Normal University, and informed consent was obtained from all participants. Participants were provided with compensation upon completion of the experiment.

Experimental design

The present study employed a 2 (trait anger: high, low) × 2 (hostile: priming condition, control condition) mixed experimental design. The between-subject variable was trait anger, and the within-subject variable was priming condition. Trait hostile attribution bias was included as a covariate, and the dependent variable was reactive aggressive behavior.

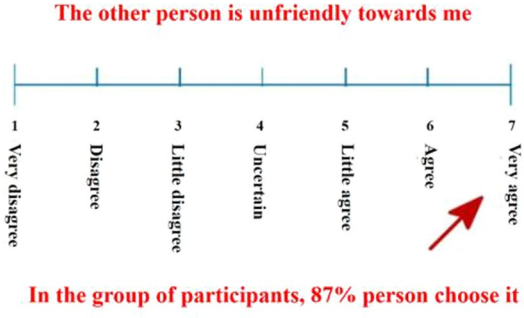

Fig. 3 Hostile priming condition

Measures

Trait anger The questionnaire was used as same as the study 1.

Trait hostile attribution bias The questionnaire was used as same as the study 1

State hostile attribution bias A State Hostile Attribution Endorsement Questionnaire was used in this study by adapting measurement tools to assess individuals' state hostile attribution bias [6, 29]. This questionnaire consisted of 10 items, requiring participants to rate their agreement on a 7-point Likert scale (1= "strongly disagree," 7= "strongly agree") regarding the perceived intentions of virtual game opponents in a competitive reaction time paradigm. The internal consistency reliability of the questionnaire in this study, as measured by Cronbach's α was 0.835

Materials and procedure

Based on the competitive reaction time paradigm in Study 1, a conformity-based priming procedure was incorporated with hostile attribution. Specifically, drawing from the definition, relevant theories, and existing measurement tools of hostile attribution bias, a state hostile attribution priming procedure was adapted based on the one developed by Li et al. (2020) that has been shown to be suitable for laboratory settings. This procedure involved presenting participants with two types of priming images to manipulate their state hostile attribution bias [30]. The hostile priming condition included sentences such as "The other person has hostile intentions toward me," "The other person is unfriendly towards me," and "The other person is unkind towards me," while the control condition included sentences such as "The other person does not intentionally harm me," "The other person does not intentionally make things difficult for me," and "The other person is just cooperating in the game." Additionally, a conformity-based manipulation was included to enhance the effectiveness of the priming, as depicted in Figs. 3 and 4.

In measuring reactive aggressive behavior, Study 2 also used the competitive reaction time paradigm, which was the same as Study 1. The experiment consisted of five stages. Unlike study 1, study 2 included a hostile attribution priming stage between the response stage and the outcome feedback stage, as shown in Fig. 5.

Statistic analysis

Data management was performed using SPSS 22.0. Descriptive statistics, repeated measures analysis of

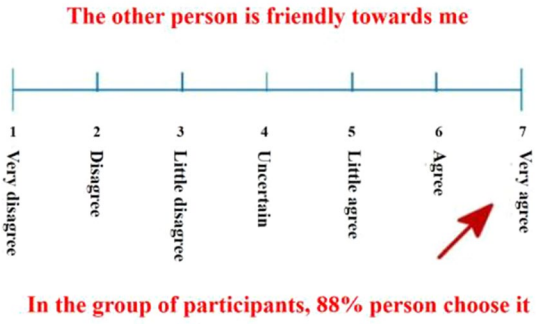

Fig. 4 Control condition

variance (ANOVA), and path analysis were used for statistical analysis.

Results

Grouping validity check

The results of an independent samples *t*-test showed a significant difference in trait anger levels between the high trait anger group and the low trait anger group, indicating that the grouping in the experiment was effective. The specific results were shown in the Table 4.

Manipulation checks

Based on the study by Barlett et al. (2017) [29] and Quan et al. (2019) [6], the State Hostile Attribution Endorsement Questionnaire was used to assess the effect of the experimental manipulation on state attribution bias.

Table 5 State hostile attribution bias in two groups ($N=62$)

Hostile	High trait anger ($n=27$)		Low trait anger ($n=35$)	
	M	*SD*	*M*	*SD*
Control condition	3.135	1.082	2.294	0.962
Priming condition	4.560	1.606	3.236	1.069

Paired samples *t*-test were conducted to examine the hostile attribution bias in both the high trait anger group and the low trait anger group of middle school students. The results indicated that there were significant differences in state hostile attribution bias between the two groups under both priming conditions (high trait anger group, $t(26)=5.327$, $p<0.001$; low trait anger group, $t(34)=7.296$, $p<0.001$). The specific results were shown in the Table 5.

The influence of trait anger and hostility guiding condition on reactive aggressive behavior of junior middle school students

The descriptive statistics for the two groups of participants under different hostile conditions were shown in Table 6.

The results of the repeated measures analysis of variance, with gender, age, and trait hostile attribution bias as covariates, showed significant main effects of trait anger, F (1, 60)=15.280, $p<0.001$, $\eta_p^2=0.211$, and priming condition, F (1, 60)=7.488, $p=0.008$, $\eta_p^2=0.116$. The interaction between the two factors was also significant,

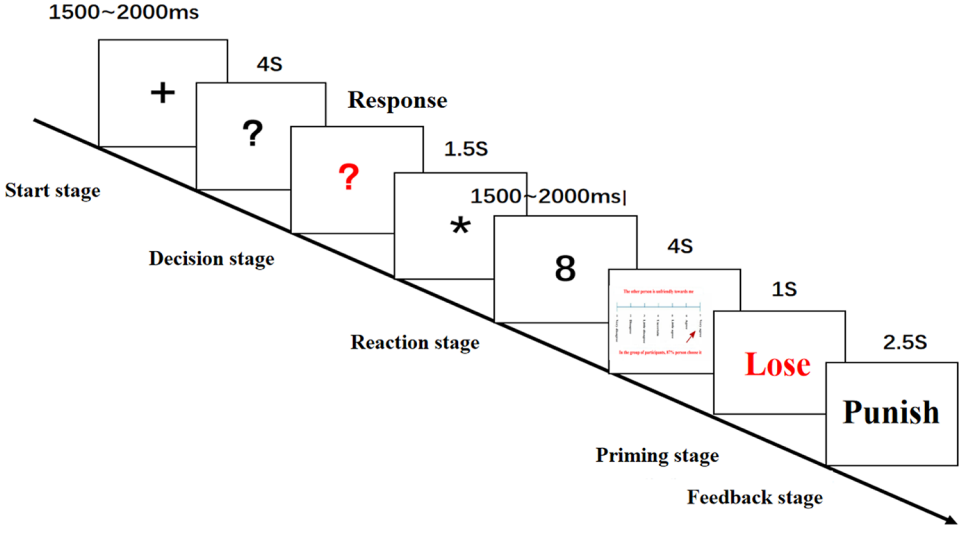

Fig. 5 Experimental procedure flowchart

Table 4 Trait anger in two groups ($N=62$)

Variable	High ($n=27$)		Low ($n=35$)			*p*	*d*
	M	*SD*	*M*	*SD*			
Trait anger	2.244	0.356	1.266	0.189	-13.944	<0.001	-3.432

Table 6 Reactive aggressive behavior in two groups ($N=62$)

Variables	High trait anger ($n=27$)		Low trait anger ($n=35$)	
	M	*SD*	*M*	*SD*
Control condition	6.558	1.638	3.849	1.523
Priming condition	7.811	1.182	4.629	1.401

F (1, 60)=4.085, p=0.048, η_p^2=0.067, as shown in Fig. 6. Furthermore, the main effect of gender was not significant, F (1, 60)=0.348, p=0.558, η_p^2=0.006, as well as age, F (2, 59)=0.208, p=0.650, η_p^2=0.004, while the main effect of trait hostile attribution bias was significant, F (1, 60)=6.145, p=0.016, η_p^2=0.097.

Simple effects analysis revealed a significant difference in reactive aggressive behavior between the high trait anger group under hostile priming condition and control condition ($M_{hostile}$ = 6.354, SD=2.270; $M_{control}$ = 5.554, SD=2.463, $p<0.001$).

Correlation

The descriptive statistics and partial correlation analysis results, with gender and age as covariates, were shown in the Table 7.

Mediating analysis

The data processing and analysis for the chain mediating model were conducted using the PROCESS plugin in SPSS. Gender and age were included as covariates. The results of the chain mediating model were as follows in Table 8; Fig. 7.

Table 8 The paths analysis of trait hostile attribution bias and state hostile attribution bias ($N=62$)

Paths	Estimate	*t*	*p*	95% CI	
				Low-CI	High-CI
TA-RAB	0.265	2.035	0.047	0.003	0.526
TA-THAB	0.656	6.759	< 0.001	0.461	0.851
TA-SHAB	0.494	3.003	0.004	0.164	0.825
THAB-SHAB	-0.058	-0.337	0.738	-0.405	0.288
THAB-RA	0.377	3.001	0.004	0.125	0.630
SHAB-RA	0.262	2.541	0.014	0.055	0.469

Note TA=Trait Anger, THAB=Trait Hostile Attribution Bias, SHAB=State Hostile Attribution Bias, RAB=Reactive Aggressive Behavior

In addition, age did not have a significant predictive effect on trait hostile attribution bias (β=0.158, p=0.236), state hostile attribution bias (β=0.287, p=0.072), and reactive aggressive behavior (β = -0.054, p=0.669). Similarly, gender did not have a significant predictive effect on trait hostile attribution bias (β=0.013, p=0.948), state hostile attribution bias (β = -0.423, p=0.079), and reactive aggressive behavior (β = -0.023, p=0.903).

The results in Table 9 indicated that trait hostile attribution bias (95% CI = [0.083, 0.438], not including 0) and state hostile attribution bias (95% CI = [0.021, 0.330], not including 0) partially mediated the effects. However, the chain mediation effect of the two variables was not significant. The direct effect accounted for 41.93% of the total

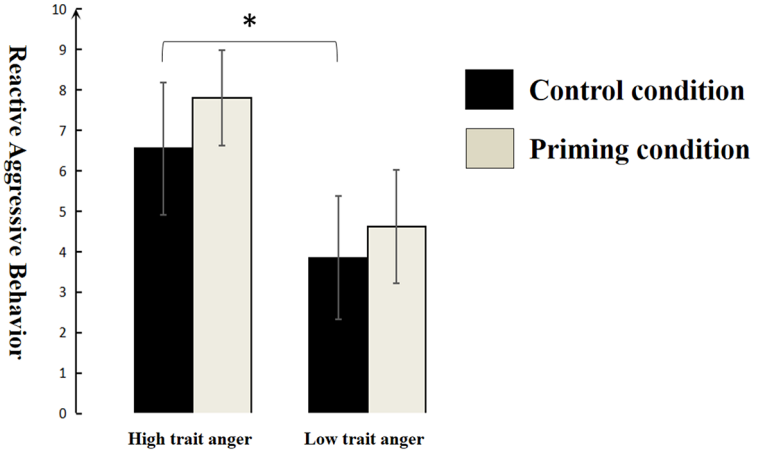

Fig. 6 Reactive aggressive behavior. $^{*}p<0.05$

Table 7 Correlation between variables ($N=62$)

Variables	*M*	*SD*	1	2	3	4
Trait anger	1.692	0.560	1			
Trait hostile attribution bias	2.916	1.102	0.664***			
State hostile attribution bias	3.736	1.437	0.432***	0.223	1	
Reactive aggressive behavior	6.014	2.054	0.652***	0.634***	0.470**	1

Note $^{**}p<0.01$, $^{***}p<0.001$

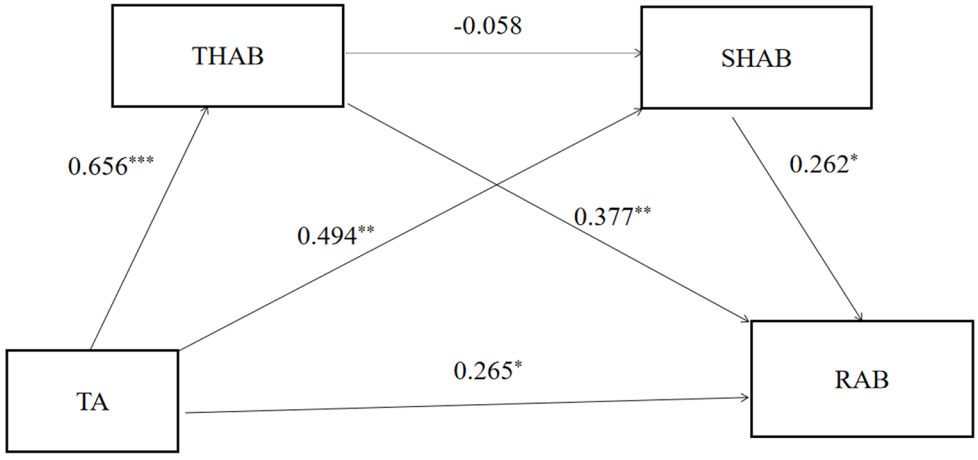

Fig. 7 Chain mediating model, TA = Trait Anger, THAB = Trait Hostile Attribution Bias, SHB = State Hostile Attribution Bias, RAB = Reactive Aggressive Behavior. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 9 The chain mediating analysis of trait hostile attribution bias and state hostile attribution bias ($N = 62$)

Effects	Estimate	95% CI		%
		Low-CI	High-CI	
Direct effect	**0.265**	**0.003**	**0.526**	**41.997%**
Indirect effect	**0.366**	**0.178**	**0.616**	**58.003%**
TA-THAB-RAB	0.247	0.083	0.438	
TA-SHAB-RAB	0.129	0.021	0.330	
TA-THAB-SHAB-RAB	-0.010	-0.090	0.058	
Total effect	**0.631**	**0.436**	**0.827**	**100%**

Note. TA = Trait Anger, THAB = Trait Hostile Attribution Bias, RAB = Reactive Aggressive Behavior

effect, while the total indirect effect accounted for 58.07% of the total effect.

Discussion

The effectiveness of the grouping was first tested in current study, and the results showed significant differences between the two groups in trait anger scores, indicating the effectiveness of the grouping. The results of the repeated measures ANOVA showed significant main effects for trait anger and instructional condition, as well as a significant interaction between trait anger and instructional condition. Based on these findings, we further examined the chain mediation effects of trait hostile attribution bias and state hostile attribution bias in the relationship between trait anger and reactive aggressive behavior. The results indicated that both trait hostile attribution bias and state hostile attribution bias played a partial mediating role, but the chain mediation effect did not reach significance.

These findings partially supported the Integrated Cognitive Model [10, 11] and the temporal pathway model of common aggressive behavior [5]. In terms of empirical research, although previous studies have not explored the mediating role of state hostile attribution bias, the view that trait anger influenced individuals' hostile attribution bias has been confirmed. Specifically, trait anger led individuals to make negative evaluations of their environment and others [31], perceived bias in threat-related information [32], and selectively attended to hostile cues [10]. Similarly, there was a close relationship between state hostile attribution bias and reactive aggressive behavior. Li et al. (2020) found that individuals with a stronger hostile attribution bias were more likely to perceive threat, betrayal, and harm in interpersonal relationships, increasing the risk of aggressive behavior [30]. Verhoef et al. (2019) conducted a meta-analysis examining the relationship between hostile attribution bias and aggressive behavior among 29,272 participants from 111 studies, and found a significant positive correlation between hostile attribution bias and aggressive behavior, with affective involvement playing a moderating role [33]. Additionally, Manning (2020) conducted a systematic review and in-depth analysis of existing literature, highlighting the close relationship between threat-related cognitive processing biases and reactive aggressive behavior in different age groups (adult samples aged 18 and above; child and adolescent samples aged 9–16) [34]. These research findings suggested that trait anger led individuals to pay more attention to hostile cues in situations and make negative evaluations of others, making it more likely for them to interpret others' intentions as hostile. Consequently, when individuals perceived hostility from others, they might attempt to retaliate through aggressive behavior.

Study 3 Intervention on reactive aggressive behavior among middle school students with high trait anger based on hostile attribution bias

The results of the study 2 indicated that trait anger significantly predicted reactive aggressive behavior, and both

trait hostile attribution bias and state hostile attribution bias mediated this relationship. Moreover, the mediating effect of trait hostile attribution bias was greater than that of state hostile attribution bias. In order to effectively improve the reactive aggressive behavior of middle school students with high trait anger, the hostile attribution bias modification training technique proposed by Van Bockstaele et al. (2020) could be used [14]. By intervening in the trait hostile attribution bias of middle school students with high trait anger, their reactive aggressive behavior in daily life could be reduced.

Methods

Participants

A total of 900 middle school students (479 males, 421 females) from two middle schools in a certain city were recruited to complete the trait anger sub-scale of the State-Trait Anger Expression Inventory as part of the screening questionnaire for current study. The participants who met the inclusion criteria then took part in the study. We estimated the required sample size using G*Power 3.1. Study 3, employed a 2 (between-subject factor) × 3 (within-subject factor) mixed design, with $f=0.25$, $\alpha=0.05$, and a statistical power of 0.8; the estimated sample size was 44. Among 900 middle school students, the top 30% in trait anger scores were assigned to the high group, while the bottom 30% were assigned to the low group. Using a simple random sampling method, 80 participants were randomly selected from the high group. While considering the average age and gender, they were randomly assigned to the experimental group and control group at the individual level. Each group consisted of 40 participants (20 males and 20 females). This selection was conducted using the "Random Sampling of Cases" function in SPSS 22.0 software. The average age of the participants was 13.392±0.977 years, ranging from 12 to 16 years. There were no significant differences between the two groups in terms of average age ($t(78) = -0.649$, $p=0.518$), trait anger at pre-test ($t(78) = -0.774$, $p=0.441$), trait hostility attribution bias ($t(78)=1.118$, $p=0.267$), and reactive aggressive behavior ($t(78) = -0.124$, $p=0.264$). The results indicated that participants of two groups were homogeneous. According to the results of the school's mental health screening, all participants in current study had normal intelligence and no conduct disorders or mental disorders. This study was approved by the Ethics Committee of Tianjin Normal University, and informed consent forms were signed by all participants, who were also given compensation after the completion of the experiment.

Experimental design

This study employed a 2 (Group: experimental group, control group) × 3 (Measurement Time: pretest, post-test, follow-up) mixed experimental design. The independent variable was hostile attribution bias, and the dependent variable was reactive aggressive behavior.

Measures

Trait anger The questionaire was used as same as the study 1.

Trait hostile attribution bias The questionaire was used as same as the study 1.

Reactive aggressive behavior This study utilized the reactive aggression subscale of the Reactive-Proactive Aggression Questionnaire to assess individuals' reactive aggressive behavior [35]. The questionnaire was revised by Chinese scholars Chen et al. (2018) based on a Chinese adolescent sample [36]. The reactive aggression subscale consisted of 11 items, scored on a 3-point Likert scale (1 = "never", 3 = "often"). Higher scores indicated higher levels of reactive aggressive behavior in individuals. The Cronbach's α coefficient for this scale in the present study was 0.903.

Plan of intervention

Based on the Social Information Processing Model, individuals with a high level of hostility attribution bias tended to interpret others' behavior as intentional provocation rather than accidental or coincidental in ambiguous social situations, and exhibited high levels of reactive aggressive behavior towards others [37]. Based on this theory, hostility attribution bias modification training aimed to reduce individual reactive aggressive behavior by improving individuals' hostility attribution bias. Hostility attribution bias modification training consisted of presenting ambiguous social situations, asking participants to make attributions about the social events, correcting individuals' hostility attribution bias, and requiring participants to make attributions in a positive manner. During the process of intervention, hostile attribution bias modification training involved presenting participants with a series of ambiguous scenarios and asking them to complete word fragments in order to attribute the situations in a positive way. In this training, a series of ambiguous situations that middle school students frequently encountered in their daily lives were presented to the participants. These ambiguous situations were obtained through interview studies. Based on previous theoretical and empirical research on ambiguous situations in adolescents, a semi-structured interview outline was developed for this study. The outline was mainly based on open-ended interviews to collect descriptions of provocative situations that middle school students commonly experienced and to formulate relevant sentences. Through interviews on the causes

of reactive aggressive behavior in middle school students, descriptive vocabulary and corresponding typical behaviors related to provocative situations were collected, coded, summarized, and classified. A total of 50 ambiguous situations that middle school students frequently experienced were obtained, involving conflicts with teachers, conflicts with parents, and conflicts with classmates.

The entire training consisted of 5 sessions, conducted over 5 weeks, with a total of 50 scenarios. In previous studies, these scenarios were presented to participants in the form of text, audio, images, or video clips [14, 38]. In this study, the scenarios were primarily presented through text, images, and video clips. In the hostile attribution bias modification training, Each training session consisted of three steps. The first step involved presenting ambiguous social situations to the participants through text, images, or videos on the computer (e.g., conflicts with teachers, conflicts with parents, conflicts with classmates). The second step involved presenting three sentences to the participants. The first sentence was a complete sentence, which participants needed to read and imagine themselves in that situation. The second sentence was a positive attribution sentence with one missing word, which participants needed to complete. The third sentence was a question asking participants to attribute the behavior of others in the situation and answer yes or no. If participants made a hostile attribution, they received incorrect feedback. For example, the first sentence presented the scenario: "When I was walking, someone stepped on my foot." The second sentence was: "This person is so careless and ___." The third sentence asked the attribution: "Did this person intentionally step on you?" If participants answered **YES** to the third sentence, they received "incorrect feedback," while answering **NO** received "correct feedback". The third step, participants were asked to reflect on the reasons for their choices and the possible consequences of those choices. They were also asked to reflect on the reasons for their incorrect choices and the direction for correction. Overall, the 50 scenarios used in current study almost covered all the situations in which middle school students might exhibit reactive aggressive behavior. Therefore, after receiving hostility attribution bias modification training, middle school students could make attributions in a positive manner when facing similar social situations in their daily lives, thus avoiding the occurrence of reactive aggressive behavior.

Procedure

In the process of research, first, both groups of participants completed the State-Trait Anger Expression Inventory-II (STAXI-II), the Chinese version of the WSAP-Hostility Scale, and the Reactive-Proactive Aggression Questionnaire (RPQ) during the pre-test. Secondly, the experimental group received hostility attribution bias modification training once a week for 40 min, for a total of 5 weeks, while the control group did not receive any intervention. Thirdly, a post-test was conducted within one week after the intervention, and a follow-up assessment of the intervention was conducted within two months after the intervention. The same measurement tools were used for all three assessments. All participants in the experimental group and control group completed questionnaires in a large classroom during the pre-test, post-test, and follow-up test. They were seated separately and were not allowed to communicate with each other during the process of research. The specific research procedure was shown in Fig. 8.

Statistic analysis

Using SPSS 22.0 software for data management, descriptive statistics, independent samples *t*-test, paired samples *t*-test, and repeated measures analysis of variance (ANOVA) were conducted for statistical analysis.

Results

Comparison between experimental group and control group

A difference test was conducted on the scores of the experimental group and the control group on various measurement indicators during the pretest, and the specific results were shown in Table 10. There were no significant differences between the two groups of subjects on the three variables during the pretest, indicating that the two groups were at the same level on the observed indicators before the experimental treatment, and there was homogeneity between the groups.

An independent samples *t*-test was conducted on the scores of both groups of subjects on various measurement indicators during the post-test, and the results were shown in Table 11. The results indicated that there were significant differences between the two groups of subjects on the indicators of hostile attribution bias and reactive aggressive behavior during the post-test, suggesting that the intervention program was effective.

Comparison between pre-test and post-test of experimental group and control group

To examine whether the intervention had an impact on the indicators for the experimental group but not the control group, a test was conducted on the differences in scores between the pre-test and post-test for the experimental group on hostile attribution bias and reactive aggressive behavior. The specific results were shown in Table 12.

To examine the changes in the control group, a paired samples *t*-test was conducted to explore the differences

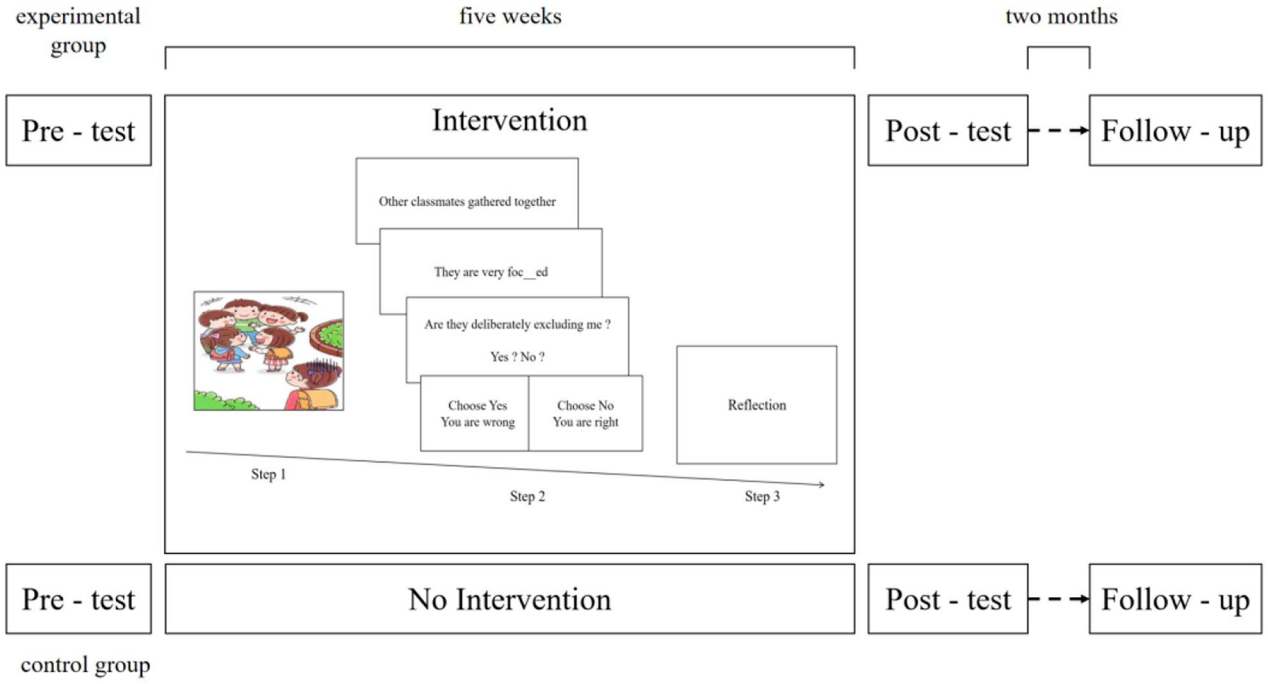

Fig. 8 Study flow chart

Table 10 Comparison of pre-test results between the two groups ($N=80$)

	Experimental group ($n=40$)		Control group ($n=40$)		*t*	*p*	*d*
	M	*SD*	*M*	*SD*			
Trait anger	2.000	0.463	1.928	0.369	−0.774	0.441	−0.172
Trait Hostile Attribution Bias	3.381	0.743	3.572	0.781	1.118	0.267	0.251
Reactive Aggressive Behavior	1.896	0.357	1.807	0.348	−1.124	0.264	−0.252

Table 11 Comparison of post-test results between the two groups ($N=80$)

	Experimental group ($n=40$)		Control group ($n=40$)		*t*	*p*	*d*
	M	*SD*	*M*	*SD*			
Trait anger	1.968	0.510	2.045	0.397	0.758	0.450	0.168
Hostile Attribution Bias	2.928	0.728	3.531	0.788	3.458	0.001	0.795
Reactive Aggressive Behavior	1.468	0.233	1.775	0.326	4.845	< 0.001	1.083

Table 12 Comparison between pre-test and post-test of experimental group ($N=40$)

	Pre-test		Post-test		*t*	*p*	*d*
	M	*SD*	*M*	*SD*			
Hostile Attribution Bias	3.383	0.743	2.946	0.731	3.362	0.002	0.532
Reactive Aggressive Behavior	1.896	0.357	1.468	0.234	6.655	< 0.001	1.052

in scores between the pre-test and post-test for the control group on the indicators of hostile attribution bias and reactive aggressive behavior. The specific results were shown in Table 13.

Comparison between pre-test, post-test and follow-up

A repeated measures analysis of variance (ANOVA) was conducted on the pre-test, post-test, and follow-up results of the two groups of participants. The results showed significant main effects for measurement time, F (2, 78) = 16.943, $p < 0.001$, $\eta_p^2 = 0.178$, and group, F (1, 78) = 14.487, $p < 0.001$, $\eta_p^2 = 0.157$, as well as a significant interaction effect when hostile attribution bias was used as the dependent variable, F (2, 78) = 16.768, $p < 0.001$, $\eta_p^2 = 0.177$. Simple effects analysis revealed a significant difference in hostile attribution bias between the

Table 13 Comparison between pre-test and post-test of control group ($N=40$)

	Pretest		Posttest		*t*	*p*	*d*
	M	*SD*	*M*	*SD*			
Hostile Attribution Bias	3.573	0.782	3.534	0.787	0.631	0.532	0.100
Reactive Aggressive Behavior	1.808	0.348	1.777	0.326	0.676	0.503	0.107

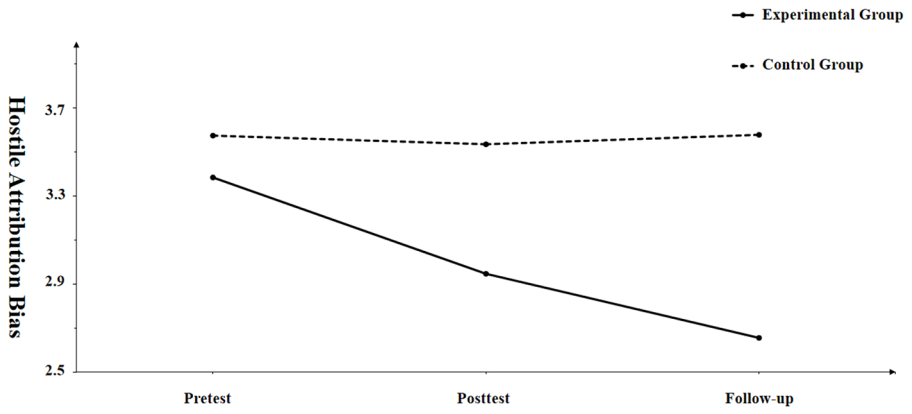

Fig. 9 Hostile attribution bias

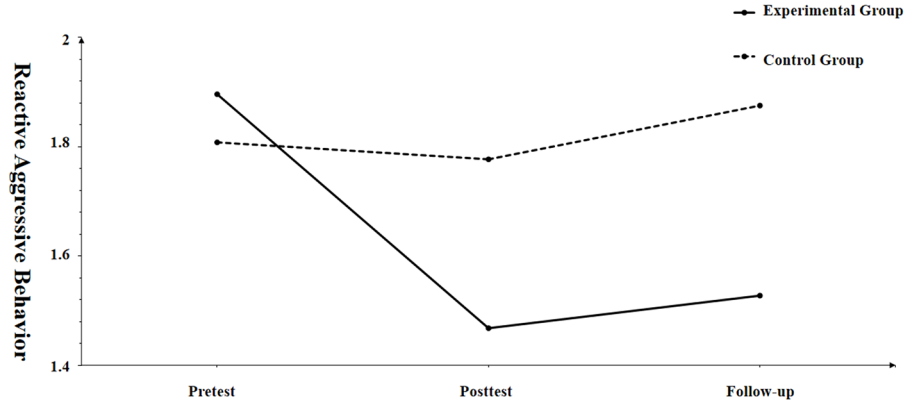

Fig. 10 Reactive aggressive behavior

experimental and control groups at the follow-up assessment ($M_{experimental\ group}$ = 2.655, SD=0.673, $M_{control\ group}$ = 3.577, SD=0.728, $p<0.001$). These results suggested that the hostile attribution bias modification training had both immediate and short-term effects as shown in Fig. 9.

On the other hand, when reactive aggressive behavior was used as the dependent variable, there were significant main effects for measurement time, F (2, 78)=22.976, $p<0.001$, $\eta_p^2=0.228$ and group, F (1, 78)=11.283, $p<0.001$, $\eta_p^2=0.126$, as well as a significant interaction effect, F (2, 78)=24.571, $p<0.001$, $\eta_p^2=0.240$. Simple effects analysis revealed a significant difference in reactive aggressive behavior between the experimental and control groups at the follow-up assessment ($M_{experimental\ group}$ = 1.527, SD=0.264, $M_{control\ group}$ = 1.875, SD=0.304, $p<0.001$). These results suggested that reducing hostile attribution bias in individuals with high trait anger had immediate and short-term effects on improving their reactive aggressive behavior, as shown in Fig. 10.

Discussion

This study utilized hostile attribution bias training to intervene in the hostile attribution bias of high trait anger middle school students in provoking situations. The results showed a significant reduction in hostile attribution bias and reactive aggressive behavior in the experimental group between pre-test and post-test, while no significant differences were found in the control group.

While previous studies have not directly intervened in the hostile attribution bias of high trait anger individuals to reduce their reactive aggressive behavior, there was evidence that intervening in an individual's hostile attribution bias could effectively reduce reactive aggressive behavior. Firstly, there was a close relationship between

hostile attribution bias and reactive aggressive behavior. For example, Gagnon and Rochat (2017) examined the risk role of hostile attribution bias in inducing reactive aggressive behavior among 176 college students [39]. The results showed a significant positive predictive effect of hostile attribution bias on reactive aggressive behavior, even after controlling for age, gender, and education level. Secondly, previous research has found that improving an individual's hostile attribution bias could lead to a reduction in reactive aggressive behavior. For instance, Van Bockstaele et al. (2020) effectively reduced aggressive behavior in individuals with high levels of aggressive behavior through hostile attribution bias training [14]. Hiemstra et al. (2019) successfully reduced hostile interpretations of facial expressions in children with high levels of hostile attribution bias through cognitive bias modification training, which not only decreased their anger arousal but also inhibited their impulse to engage in reactive aggressive behavior [15]. Ren et al. (2021) intervened in the hostile attribution bias of 56 male adolescent offenders aged 16–18 in China to improve their aggressive behavior. The results showed a significant reduction in hostile attribution bias and self-reported physical aggressive behavior among the male adolescent offenders [40].

General discussion

Trait anger and reactive aggressive behavior among middle school students

The results of this study indicated that trait anger significantly predicted reactive aggressive behavior, with high trait anger middle school students showing higher levels of reactive aggressive behavior compared to low trait anger students. While the direct impact of trait anger on reactive aggressive behavior has been supported by previous theoretical research [9–11] and empirical studies [41, 42], the relationship between trait anger and reactive aggressive behavior was mostly based on cross-sectional questionnaire evidence [27, 43]. For example, Wang et al. (2020) examined the relationship between trait anger and bullying behavior in 435 Chinese adolescents, and the results showed a significant positive correlation between bullying behavior and trait anger [44]. Dannisworo et al. (2019) investigated the relationship between trait anger and violent behavior in 366 male university students in Java, and the study found that trait anger also increased the risk of violent behavior [45]. The negative impact of trait anger was not only present in the general population but also in special populations, such as Cao and An (2019) who explored the relationship between trait anger and aggressive behavior in 150 individuals with substance use disorders, and the results showed a close association between trait anger and aggressive behavior in individuals with substance use disorders [46]. In addition, the negative effects of trait anger extend to virtual environments, such as Yang et al. (2020) who examined the predictive role of trait anger on cyberbully behavior in 455 Chinese adolescents, and the results showed that trait anger also increased the risk of cyberbully behavior [47]. Veenstra and Schneider (2017) conducted motivation tendency training on high trait individuals, with the experimental group and control group receiving either avoidance or approach training [48]. The avoidance group had to consistently avoid angry faces and make neutral actions towards happy faces during the training, while the approach group had to approach angry faces and make neutral actions towards happy faces. The results showed that avoidance training effectively reduced individual's (especially high trait anger individuals) aggressive behavior and improved their anger management skills. In summary, compared to individuals with high trait anger, those with low trait anger had stronger empathy and considered the feelings of others more, inhibiting their expression of reactive aggressive behavior [5, 44]. However, some studies have found that the main effect of trait anger on reactive aggressive behavior was not significant [49]. Specifically, this study found that the utility of trait anger depends on provocation situations, and the direct predictive effect of trait anger on reactive aggressive behavior was not significant. In addition, for middle school students, strong emotional fluctuations were a typical characteristic of their development of nerves and social cognition at this stage, and it might also be a critical period for the development of brain circuits related to reactive aggressive behavior (such as emotional response, emotion regulation, decision-making, etc.). The amygdala and ventral striatum of individuals with high trait anger might be more prone to over activate and led to high-intensity arousal of negative emotions, which in turn triggered intense reactive aggressive behavior [50].

Mediation of hostile attribution bias

The results of this study found that both trait hostile attribution bias and state hostile attribution bias could mediate the relationship between trait anger and reactive aggressive behavior, and intervention on trait hostile attribution bias in high-trait anger middle school students could effectively reduce their reactive aggressive behavior. Although a few studies have analyzed the mediating role of trait hostile attribution bias in the relationship between trait anger and reactive aggressive behavior using cross-sectional questionnaire methods [49, 51], there was little research on the role of different states of hostile attribution bias in the effect of trait anger on reactive aggressive behavior in middle school students.

On one hand, regarding the mediating role of trait hostile attribution bias, for high-trait anger middle school

students, they might have selective attention to hostile social cues and tend to interpret their behaviors in a hostile manner. Moreover, due to their immature emotion regulation and self-control abilities, they were more likely to perceive threats in daily social processing, which made them more prone to processing information in a hostile manner and forming a high level of trait hostile attribution bias. This might further trigger high levels of anger or retaliatory motives and subsequently lead to reactive aggressive behavior [52].

On the other hand, regarding the mediating role of state hostile attribution bias, although there was no direct investigation into the mediating role of state hostile attribution bias, the temporal pathway model proposed by Li & Xia (2020) emphasized that both trait and state hostile attribution bias could mediate the relationship between trait anger and aggressive behavior [5]. It might be because individuals with high-trait anger were more likely to activate hostile schema stored in memory and process the stimulus information as harmful under the influence of external stimuli, further activating brain regions such as the orbitofrontal cortex and the ventrolateral prefrontal cortex [6], which were closely associated with retaliatory motives and subsequently activated reactive aggressive behavior. However, the cognitive processing of hostile attribution bias involved multiple aspects such as attribution of intent, hostile cognition, and perception of threat. The current research has not delved deeper into the processing of different stages of hostile attribution bias in individuals with trait anger and the brain regions involved in the manifestation of reactive aggressive behavior. Therefore, further exploration through other studies was still needed in the future.

Current study supported and extends the Comprehensive Cognitive Model [10, 11]. The model suggested that high-trait anger made individuals more prone to interpret situations with hostility, which in turn triggered their hostile attribution bias and ultimately led to reactive aggressive behavior. The results of this study not only validated the Comprehensive Cognitive Model but also provided an expansion to the model. Specifically, high-trait anger led to the development of high-trait hostile attribution bias in individuals, making them more likely to interpret situations with hostility and develop high-state hostile attribution bias, which ultimately resulted in high levels of reactive aggressive behavior.

Limitations and further direction

Current study still had the following limitations that need further exploration in the future. In terms of sample size, although the sample sizes of the three studies met the requirements of G*Power statistical tests, future research could further expand the sample size to test the stability of the current study. Regarding the tracking of intervention effects, although the current study found a significant reduction in hostility attribution bias and reactive aggressive behavior in the experimental group participants through pre-test, post-test, and follow-up tests, while no significant changes were observed in the control group participants, future research could track intervention effects further through long-term, multi-observation point longitudinal studies. In terms of research methods, the current study mainly used questionnaire and behavioral experimental methods to investigate the relationship between trait anger and reactive aggressive behavior in middle school students, as well as the mediating role of hostility attribution bias and intervention effects. However, existing research based on ERP and fMRI techniques has identified important brain regions associated with reactive aggressive behavior [53], and some studies have effectively reduced individual reactive aggressive behavior using transcranial magnetic techniques [54]. Therefore, future research could combine electrophysiological techniques to further investigate the neural mechanisms of trait anger, hostility attribution bias, and their impacts on reactive aggressive behavior, and intervene in individual reactive aggressive behavior based on transcranial magnetic or transcranial electric techniques. In terms of intervention methods, current study mainly used hostility attribution bias modification techniques to intervene in the hostility attribution bias of highly trait-anger middle school students and reduced their reactive aggressive behavior. Future research could explore interventions for highly trait-anger middle school students through other methods (such as aggression replacement training [55], mindfulness practices [56], etc.).

Conclusion

Trait anger could predict the reactive aggressive behavior of middle school students, with trait hostility attribution bias and state hostility attribution bias mediating this relationship. Intervening in the hostility attribution bias among high-anger middle school students could effectively reduce their reactive aggressive behavior.

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Author contributions

All the authors confirm contribution to the paper as follows: Conceptualization of the study: Shuang L., Wen L.Investigation (collect data): Shuang L.Formal analysis: Gonglu C.Supervision: Xuejun Bai.Writing - original draft: Shuang LWriting - review and editing: Gonglu C.All authors reviewed the results and approved the final version of the manuscript.

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Data availability
Sequence data that support the findings of this study have been deposited in the 10.17605/OSF.IO/KWCBP.

Declarations

Ethical approval
All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 elsinki declaration and its later amendments or comparable ethical standards. This study was conducted in accordance with the Declaration of Helsinki and approved by the Human Research Ethics Committee of the Faculty of Psychology, Tianjin Normal University (protocol number: 2022121001, date of approval: 10 December 2022).

Consent for publication
Not applicable.

Informed consent
Informed consent was obtained from all individual participants and their parents included in the study.

Conflict of interest
No potential conflict of interest was reported by the authors.

Competing interests
The authors declare no competing interests.

Author details
[1]Department of psychology, Faculty of Education, Guangxi Normal University, Guilin 541004, China
[2]Faculty of Psychology, Tianjin Normal University, Tianjin 300387, China
[3]College of Psychology, Liaoning Normal University, Dalian 116029, China

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