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ORIGINAL RESEARCH

Autistic Traits and Aggressive Behavior in Chinese College Students: A Serial Mediation Model and the Gender Difference

Chenghui Tan[1,*], Huan Song[2,3,*], Shanshan Ma[3,4], Xinyu Liu[3,5], Yuan Zhao[6]

[1]Department of Psychology, Renmin University of China, Beijing, People's Republic of China; [2]School of Educational Science, Neijiang Normal University, Neijiang, People's Republic of China; [3]School of Education, Soochow University, Suzhou, People's Republic of China; [4]School of Marxism, Nanjing Forestry University, Nanjing, People's Republic of China; [5]Department of Psychology, Wuhan University, Wuhan, People's Republic of China; [6]Police Officer Academy, Shandong University of Political Science and Law, Jinan, People's Republic of China

*These authors contributed equally to this work

Correspondence: Yuan Zhao, Police Officer Academy, Shandong University of Political Science and Law, Jinan, People's Republic of China, Email sdjnzhaoyuan@163.com

Background: The existence of aggressive behavior in autism spectrum disorders (ASD) raises questions about whether cognitive and emotional factors in social information processing play a role between autistic traits (ATs) and aggressive behavior in the general population, especially in the context of Chinese culture. Moreover, given a possible gender difference in these variables, the study aimed to examine the effect of ATs on aggressive behavior, and the potential mediating role of hostile attribution bias and alexithymia on this association, as well as gender difference.

Methods: 850 Chinese college students participated in the assessment, including their ATs, hostile attribution bias, alexithymia, and aggressive behavior. Pearson correlation, mediation effects analyses, and multiple-group comparison were conducted.

Results: The results indicated that ATs indirectly predicted increased aggressive behavior through attribution bias and alexithymia. Gender difference in mediating effects was revealed: ATs indirectly predicted increased aggressive behavior through the serial mediating effect only in males.

Conclusion: Hostile attribution bias and alexithymia completely mediated the association between ATs and aggressive behavior, which contained the separate mediating effects of (a) hostile attribution bias and (b) alexithymia and the serial mediating effect of (c) hostile attribution bias and alexithymia. Gender differences in mediating effects were found only in the serial mediating effect, which was significant in males but not in females. The findings revealed the internal mechanism of ATs affecting aggressive behavior and gender difference, which have implications for the intervention of aggressive behavior of individuals with autism and those with high levels of ATs.

Keywords: autistic traits, aggressive behavior, hostile attribution bias, alexithymia, serial mediating effect, gender difference

Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by deficits in social communication and the presence of restricted interests and repetitive behaviors.[1] The Centers for Disease Control and Prevention (CDC) estimates about 1.68% of United States (US) children aged 8 years (or 1 in 59 children) are diagnosed with ASD.[2] It is noteworthy that ASD is more prevalent in males, with a male-to-female ratio closer to 3:1 as per a recent meta-analysis.[3] Epidemiological evidence showed that autistic symptoms as a dimensionally-quantifiable personality trait are widely and continuously distributed across the general population.[4] Self-reported autism-spectrum quotient (AQ) questionnaires were used to measure the autistic traits (ATs) of individuals.[5] In general, people diagnosed with ASD score at the extreme end of this distribution.[6] Males in the general population score higher on the AQ than do females. Baron-Cohen has proposed the extreme male brain theory of autism, which attempts to explain the remarkable similarities between traits

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generally associated with human "maleness" and traits associated with the autism spectrum.[7] The theory posits that people with autism process the world through a "male" lens and take an interest in stereotypically male topics. And they may have trouble with tasks that women are supposedly better at, such as grasping social cues. Moreover, individuals with ATs often show similar behavior patterns as ASD, such as unsociable, outspoken, lack of imagination, preference for solitude, and difficulty expressing emotions.[8] In addition to the typical clinical symptoms, people with autism often have other complications and problematic behaviors, such as hyperactivity, anxiety, and aggression.[9–11] Among them, aggressive behavior not only seriously affects the daily life of individuals with ASD, but also increases the risk of symptom deterioration.[12] Existing studies have found that individuals with ASD, especially those with intellectual impairment, are more likely to self-harm and engage in aggressive behavior compared to other populations.[13–15] However, the relationship between ATs and aggressive behavior and its possible influencing factors in the general population is unclear, especially in the context of Chinese culture. For Chinese people, maintaining a good relationship with others is important.[16] In contrast to Western cultures that often promote open emotional expression, Chinese cultures prioritize emotional restraint to maintain interpersonal harmony. Thus, proactive aggression such as physical aggression may be seen as a threat to harmony and strongly discouraged by both educators and parents. Research has also shown that Chinese college students are more inclined to express angry and hostile by indirect ways instead of direct physical aggression.[17] Therefore, within the context of Chinese culture, the association between ATs and aggressive behavior may be contingent upon indirect mediating factors rather than direct influences.

Autistic Traits and Aggressive Behavior

Aggressive behavior is the act of intentionally hurting another person in any form.[18] The Simons Simplex Collection and the Autism Treatment Network showed that more than 50% of individuals with ASD reported aggressive behavior toward others.[19,20] Furthermore, aggressive behavior is also be affected by the severity of autism symptoms,[21] and in turn increases their stereotyped and repetitive behavior.[19] Since the concept of aggressive behavior is characterized by rich meaning and multi-dimensional, researchers usually divide it into different types according to certain criteria and then select some subtypes for research. For instance, according to different causes and functions, aggressive behavior can be divided into proactive aggression and reactive aggression.[22] The former one refers to well-planned instrumental aggression with a specific purpose, in which the attacker takes pleasure in the achievement of the goal (eg, "I want the toy in his hand, so I will snatch it from him"). The latter is a defensive or retaliatory reaction that occurs when an individual directly or mistakenly perceives provocation or threat, often accompanied by emotional experience such as anger and hostility (eg, "He soiled my shoes on purpose, so I am going to beat him").[23] This classification not only takes the emotional arousal of the attacker into account but also highlights the causes for the aggressive behavior. Considering the possible differences of individuals with ASD and ATs in cognitive and language skills, other classifications of aggression, such as verbal aggression, indirect aggression, and implicit aggression, do not suitable for this population. Moreover, it has been found that aggressive behaviors in children with ASD included both proactive aggression such as physical aggression and reactive aggression such as hostile revenge.[12] Thus, the classification of proactive-reactive aggression was used in this study to measure aggressive behavior. Furthermore, aggressive behavior is also be affected by the severity of autism symptoms,[21] and in turn increases their stereotyped and repetitive behavior.[19]

The Role of Hostile Attribution Bias

To explain the emergence of aggressive behavior from the perspective of cognitive processing, the social information processing (SIP) model proposed that when faced with the same situation,[24] the key to determine the behavior of individuals is how to process and interpret situational information. When they make hostile attribution and interpretation of the stimulus, the possibility of an aggressive response will increase. The tendency to perceive or interpret ambiguous situations or stimuli as threatening and attribute the intentions of others to hostility is called hostile attribution bias,[25,26] which reflects the bias of information interpretation, has been proved to be an important cognitive variable in triggering aggressive behavior.[27] A recent cross-sectional study of adults from the general population found a significant positive correlation between hostile attribution bias and aggressive behavior.[28] For individuals with ASD, it has been found that due to their atypical attention and interpretation of situational cues,[29] biased social information processing patterns

impaired their understanding of multiple viewpoints which make them more likely to interpret the intentions of others as hostile.[30] Even in benign social situations, children with ASD made more attributions of hostile intent, gave more positive evaluations of aggressive responses, and showed more externalizing behaviors compared to the control group.[30] Recent studies have also found that when faced with negative outcomes, individuals with higher levels of ATs tend to attribute others' intentions to intentional rather than accidental ones, indicating increased attribution of hostile intentions.[31]

The Role of Alexithymia

In addition to cognitive variables, the influence of emotional variables on aggressive behavior should in no way be ignored. The impairments in emotion recognition and empathy make autistic individuals often accompanied by alexithymia which characterized by difficulty in recognizing, expressing, and describing emotions in language, lack of imagination, extroverted thinking that relies on external stimuli instead of internal experience.[32,33] Alexithymia is not only a stable personality trait composed of multiple dimensions but also a secondary symptom of psychosomatic diseases.[34] Jasinski et al indicated that individuals with alexithymia might show more anger due to the difficulty in accurately distinguishing the emotions they experience in a provocative situation, which increases the risk of aggressive behavior.[35] Some studies have further claimed that, rather than the negative emotion (anger) itself, the inability to express the negative emotions and effective communication with others are the reasons why people engage in destructive aggression.[36] In other words, if someone lacks the ability to adequately regulate and manage related emotions they are feeling,[37] the possibility of aggressive behavior driven by strong emotions will increase significantly. Studies have shown a direct link between alexithymia and aggressive behavior in different groups, from the general population to the clinical population.[38] In addition, more than half of individuals with ASD have comorbidities with alexithymia, which is strongly associated with their core symptoms,[39] and alexithymia is also an important mediating variable between ATs and other variables.[40]

Hostile Attribution Bias and Alexithymia

Based on the SIP model, moreover, Lemerise and Arsenio integrated personality and emotional factors into the original cognitive model. According to the revised model,[41] Smeijers, Benbouriche & Garofalo proposed that emotion, emotional regulation, and cognitive variables have an interactive effect in predicting aggressive behavior.[42] Studies have indicated that alexithymia is related to cognitive processing, especially the cognitive bias in information processing will affect the recognition and understanding of emotions.[43] Meanwhile, a comparative study of violent and non-violent criminals found that hostile attribution bias is related to the impairment of emotion recognition, that is, the higher hostile attribution bias of violent criminals makes it more difficult to accurately identify the emotions of others.[44] Recent studies have also indicated that hostile cognition can influence aggressive behavior through the mediating role of affective empathy.[45–47] It means that continuously focus on hostile interpretation reduces their ability to regulate emotions, which makes it difficult to understand the emotions of others and increases the likelihood of aggressive behavior.[48] In addition, according to the cognitive (attribution)-emotion-action model proposed by Weiner,[49] attribution will trigger the corresponding emotional feelings which further provide the motivation and direction of behavior. For autistic individuals, hostile intention attribution might make them misinterpret situational cues and other's emotions,[36] thereby increasing the likelihood of aggressive response.

Gender Differences

Finally, research has shown that males had significantly higher levels of ATs than females.[7,50] According to the extreme male brain theory of autism, autism can be considered as an extreme of a "male brain" characterised by increased systemising and decreased empathising.[7] Females with ASD are more inclined to acknowledge their inappropriate emotions when they engage in camouflaging and subsequently suppress their inappropriate behaviors to appear more socially conventional, but not in males.[51] Moreover, researches demonstrated that compared to healthy controls, boys with ASD showed more reactive aggression when they experienced mild aggressive attacks, while girls reacted less aggressively.[15] Therefore, this study intends to test whether there are gender differences in the mediation model.

The Current Study

Based on the general aggression model (GAM) proposed by Anderson and Bushman,[18] the role of cognition, emotion, and arousal on the relationship between personality and aggression should be considered. However, it is still a lack of study on examining the cognitive and emotional variables associated with ATs and aggressive behavior to investigate the possible mechanisms of aggressive behavior in individuals with ATs in a general population. Thus, the current study aimed to examine the effect of ATs on aggressive behavior, and the potential mediating role of hostile attribution bias and alexithymia on this association, as well as explore a possible gender difference in the context of Chinese culture. So as to provide theoretical guidance for the intervention and prevention of aggressive behavior of individuals with autism and those with high levels of ATs.

Based on the existent literature, we hypothesize that (1) there was a significant positive correlation between autistic traits, hostile attribution bias, alexithymia, and aggressive behavior; (2) ATs can positively predict aggressive behavior; (3) hostile attribution bias plays a mediating role between ATs and aggressive behavior; (4) alexithymia plays a mediating role between ATs and aggressive behavior; (5) hostile attribution bias and alexithymia play a serial mediating role in the relationship between ATs and aggressive behavior. Finally, based on the possible gender differences mentioned above, we further conduct a multiple-group comparison analysis on the mediation model to assess variations across different groups.

Methods

Participants

The minimum sample size was 178 based on a medium effect size of 0.15, α of 0.05 and a power of 0.90 (using G*power 3.1 version).[52] A total of 947 Chinese college students from universities in Anhui and Jiangsu provinces were selected to participate in an online questionnaire survey using convenient sampling. These students hail from 25 provinces, municipalities, and autonomous regions in China, including regions such as Beijing, Heilongjiang, Shandong, and Guangdong. After excluding invalid questionnaires with incomplete answers and short completion times, 850 effective questionnaires were finally obtained (424 males, 426 females, average age = 20.66 years, *SD* = 1.98, range 17–30), including 421 first-year students, 111 sophomores, 121 juniors, 117 seniors, and 80 postgraduates. Among them, 292 were single-child and 558 were non-single-child. This study was approved by the Ethics Committee of Soochow University, which is accordance with the Declaration of Helsinki. All participants have no known diagnosis of neurological disease, psychiatric problems, or head injury. Participants provided informed consent prior to completing the demographic measures and each of the questionnaires, ensuring their consent to participate in the study. The whole data collection was done in accordance with the principles of voluntariness and confidentiality. All participants had been informed that they could skip any question that made them feel uncomfortable or abandon the study at any time.

Materials and Measures

Autism Spectrum Quotient

The Autism-spectrum Quotient (AQ), compiled by Baron-Cohen et al,[5] was used to assess the level of ATs of participants in the current study. Zhang et al revised it into a Chinese version and confirmed its validity in both clinical and non-clinical samples in China.[53] There are 50 items in the total scale, which are composed of five dimensions: social skills (eg, "I prefer to do things with others rather than on my own"), attention switching (eg, "I prefer to do things the same way over and over again"), attention to details (eg, "I often notice small sounds when others do not"), verbal communication (eg, "Other people frequently tell me that what I've said is impolite, even though I think it is polite"), and imagination (eg, "If I try to imagine something, I find it very easy to create a picture in my mind"). Each question includes four options: completely agree, partially agree, partially disagree, and completely disagree, using a scale of 0–1. Among them, 24 forward scoring questions choose "strongly agree" or "partially agree" as 1 point, choose "partially disagree" or "strongly disagree" as 0 points, and the other 26 reverse questions are the opposite. The higher the score, the higher the level of ATs. The internal consistency coefficient of the scale in this study was 0.78.

Toronto Alexithymia Scale

The Toronto Alexithymia Scale (TAS), compiled by Bagby et al,[34] was adopted to measure participants' alexithymia. The scale consists of three dimensions: emotion recognition disorder (eg, "I am often confused about what emotion I am feeling"), emotion description disorder (eg, "It is difficult for me to find the right words for my feelings"), and extroverted thinking (eg, "I prefer to analyze problems rather than just describe them"). Participants were asked to answer the 20 items on a 5-point Likert-type scale ranging from "strongly disagree" to "strongly agree", and a high score indicates a high degree of alexithymia. The internal consistency coefficient of the scale in this study was 0.84.

Word Sentence Association Paradigm for Hostility

The study utilized the Word Sentence Association Paradigm for Hostility (WSAP - Hostility), developed by Dillon et al to measure hostile attribution bias in this sample.[54] The scale has a total of 16 items, containing 16 sentences of different ambiguous situations (eg, "Someone has stained your carpet"), followed by a hostile-related word (eg, "disrespectful"). Each item is rated on a 6-point Likert scale ranging from "completely unrelated" to "completely related" about the degree of relevance between hostile words and situational sentences. The average ratings of all items were used to measure the degree of hostile attribution bias. The Cronbach's coefficient alpha of the scale in this study was 0.96.

Reactive-Proactive Aggression Questionnaire

The Reactive-Proactive Aggression Questionnaire (RPQ),[55] which consisted of two subscales of proactive aggression (eg, "Had fights with others to show who was on top") and reactive aggression (eg, "Yelled at others when they have annoyed you"), was adopted to measure participants' aggressive behavior. Each subscale has 10 items and is answered on a 6-point Likert scale ranging from "never" to "always". The participants' tendency to act aggressively was reflected in the score. In this study, the Cronbach's coefficient alpha of the total scale was 0.89, and the reliability of each subscale was $\alpha = 0.83$ for reactive aggression and $\alpha = 0.87$ for proactive aggression.

Procedure

All questionnaires were administered anonymously online because of epidemic prevention and control in China. The online survey platform Wenjuanxing (https://www.wjx.cn) was utilized for data collection. The college students were recruited to send questionnaire links complying with the principles of voluntariness and data confidentiality. According to the instructions at the beginning of each questionnaire, participants were informed to fill out questionnaires in regulation. After completing all the questions conscientiously, participants will receive 3 yuan as a reward. Finally, each collected questionnaire was checked by the researcher to remove invalid ones.

Statistical Analysis

Data were analyzed using SPSS 26.0 and Amos 21.0. Common method deviation was procedurally controlled through the anonymous method and reverse scoring items. Then, using a Harman single factor test to conduct the common method bias test.[56] The results showed that 20 factors with eigenvalues greater than 1. The total variance as explained by the first factor without rotation is 12.93%, far less than 40%, indicating that there was no significant common method deviation. The correlation between variables was analyzed using Pearson correlations. Amos 21.0 was used to construct a structural equation model to test the mediating effect and gender difference. The bias-corrected nonparametric percentile Bootstrap method (based on 5000 bootstrapped samples) was adopted to analyze mediation.[57] If the 95% bootstrap confidence interval (CI) did not include 0, the indirect effect would be considered significant.

Results

Means, Standard Deviations, and Correlation Matrices of Variables

The descriptive statistics of the variables as shown in Table 1. The results of correlation analysis indicated that there was a significant positive correlation between autistic traits, hostile attribution bias, alexithymia, and aggressive behavior ($p < 0.01$).

Table 1 Means, Standard Deviations, and Correlation Between Variables of Interest

Variables	Mean	SD	1	2	3	4	5	6
1. Gender[0]	0.50	0.50	–					
2. Age	20.66	1.98	0.28**	–				
3. Autistic traits	21.30	5.38	−0.02	−0.01	–			
4. Hostile attribution bias	51.43	20.24	0.02	0.06	0.09**	–		
5. Alexithymia	54.96	9.40	−0.08*	−0.10**	0.39**	0.28**	–	
6. Aggressive behavior	42.21	9.59	−0.23**	−0.03	0.11**	0.28**	0.34**	–

Notes: Gender [0]= female. *$p < 0.05$, **$p < 0.01$.

Mediation Analysis

Amos 21.0 was used to construct a structural equation model to test the mediating effect. First, the total effect of ATs on aggressive behavior was tested after controlling for gender, and the pathway coefficient was significant ($\gamma = 0.11$, $t = 3.16$, $SE = 0.06$, $p < 0.01$), which indicated that ATs could positively predict aggressive behavior. Second, adding hostile attribution bias and alexithymia as mediating variables into the model, the path model as shown in Figure 1. The fitting results of the structural equation model showed a good fitting degree (χ^2/df =5.59, NFI = 0.90, GFI = 0.97, CFI = 0.91, IFI = 0.91, RMSEA = 0.07). As shown in Figure 1, the direct effect of ATs on aggressive behavior was not significant after adding mediating variables ($\beta = 0.03$, $p = 0.60$). ATs significantly and positively predicted hostile attribution bias ($\beta = 0.15$, $p < 0.001$), hostile attribution bias significantly and positively predicted aggressive behavior ($\beta = 0.25$, $p < 0.001$). ATs significantly and positively predicted alexithymia ($\beta = 0.50$, $p < 0.001$), alexithymia significantly and positively predicted aggressive behavior ($\beta = 0.30$, $p < 0.001$). Moreover, hostile attribution bias significantly and positively predicted alexithymia ($\beta = 0.20$, $p < 0.001$). Based on this information, hostile attribution bias and alexithymia mediated the relationship between ATs and aggressive behavior, which contained three significant mediating pathways: the mediating effects of (a) hostile attribution bias and (b) alexithymia, and the serial mediating effect of (c) hostile attribution bias and alexithymia.

Furthermore, the bias-corrected nonparametric percentile Bootstrap method (based on 5000 bootstrapped samples) was adopted to analyze mediation and estimate confidence intervals.[57] The results indicated that the three mediating pathways in the model were significant. Specifically, the mediating effect value of alexithymia was 0.15, accounting for 71.43% of the total effect; the mediating effect value of hostile attribution bias was 0.03, accounting for 14.29% of the total effect; and the serial mediating effect value of hostile attribution bias and alexithymia was 0.01, accounting for 4.76% of the total effect. The direct predictive effect of ATs on aggressive behavior in the model, however, was not significant (95% CI [−0.084, 0.118]). Combined with the above results, it can be explained that hostile attribution bias and alexithymia completely mediated the influence of ATs on aggressive behavior. The total indirect effect value came to 0.19, accounting for 90.48% of the total effect (0.21) of ATs on aggressive behavior (see Table 2).

Gender Difference Test of Mediation Model

First of all, the mediation effect models were tested for male and female samples respectively. The fitting index was in the acceptable range (see Table 3), indicating that cross-group comparative analysis can be carried out. Using the

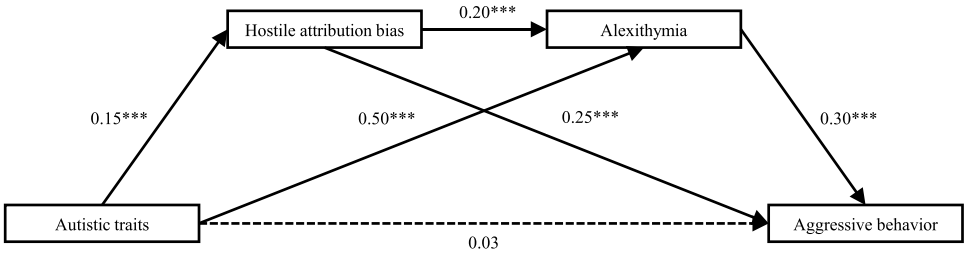

Figure 1 The mediating path model showing the influence of autistic traits on aggressive behavior. ***$p < 0.001$.

Table 2 Mediation Effect Analysis of Model

	Indirect Effect Values	*SE*	Relative Mediation Effect	95% Confidence Interval
1. Total indirect effect	0.19	0.03	86.36%	[0.142, 0.254]
2. Autistic traits → Hostile attribution bias → Aggressive behavior	0.03	0.01	14.29%	[0.013, 0.058]
3. Autistic traits → Alexithymia → Aggressive behavior	0.15	0.03	71.43%	[0.101, 0.201]
4. Autistic traits → Hostile attribution bias → Alexithymia → Aggressive behavior	0.01	0.01	4.76%	[0.003, 0.012]

Table 3 Comparison of Gender Differences in the Mediating Effect of Models

Model	χ^2	*df*	GFI	NFI	CFI	RMSEA
M_{male}	2.98	23	0.97	0.88	0.91	0.068
M_{female}	2.44	23	0.97	0.92	0.95	0.058
M_1	2.71	46	0.97	0.90	0.93	0.045
M_2	2.76	58	0.96	0.87	0.91	0.046

multiple-group comparison method in the structural equation model, the unrestricted model (M1) and the model with the same structural coefficient (M2) were set. Moreover, the fitting results of the model showed a high fitting degree, compared with M1, M2's $\Delta\chi^2(12) = 35.74$, $p < 0.01$, indicating that there are significant gender differences in the mediating effect of hostile attribution bias and alexithymia.

The mediating model of male and female groups was shown in Figures 2 and 3. For the male group, the direct predictive effect of ATs on aggressive behavior was not significant ($\beta = 0.01$, $p = 0.89$), but the predictive effect on hostile attributional bias was significant ($\beta = 0.19$, $p < 0.001$) (see Figure 2). For the female group, ATs did not significantly predict both aggressive behavior ($\beta = 0.09$, $p = 0.20$) and hostile attribution bias ($\beta = 0.07$, $p = 0.23$) (see Figure 3). In both models, the predictive effect of Ats on alexithymia, alexithymia on aggressive behavior, hostile attribution bias on alexithymia were all significant ($p < 0.001$).

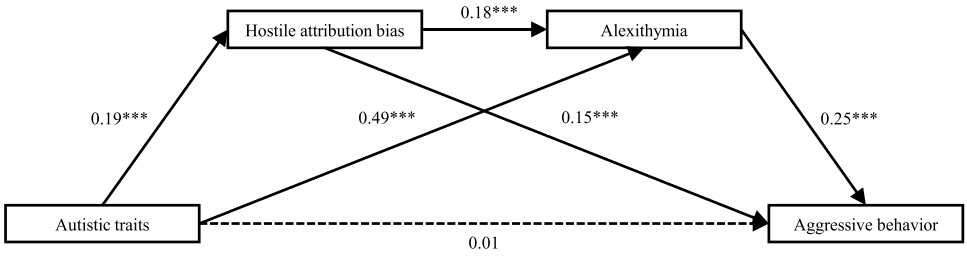

Figure 2 The mediating path model of male group. ***$p < 0.001$.

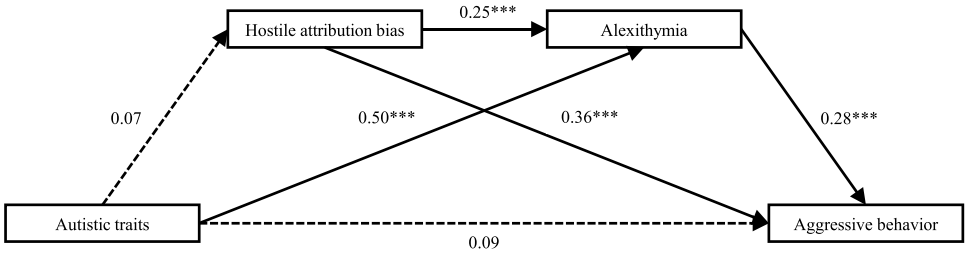

Figure 3 The mediating path model of female group. ***$p < 0.001$.

Table 4 Mediation Effect Analysis of Male and Female Groups

	Male		Female	
	Indirect Effect Values	**95% Confidence Interval**	**Indirect Effect Values**	**95% Confidence Interval**
1. Autistic traits → Aggressive behavior direct effect	0.01	[−0.145, 0.168]	0.09	[−0.029, 0.215]
2. Autistic traits → Hostile attribution bias → Aggressive behavior	0.03	[0.005, 0.056]	0.02	[0.018, 0.067]
3. Autistic traits → Alexithymia → Aggressive behavior	0.11	[0.048, 0.197]	0.14	[0.077, 0.211]
4. Autistic traits → Hostile attribution bias → Alexithymia → Aggressive behavior	0.01	[0.001, 0.011]	0.01	[−0.005, 0.016]

The mediating effect test results of male and female groups were shown in Table 4. Specifically, the three indirect mediating pathways in the male group model were at a statistically significant level; the direct effect was not significant because the 95% CI includes 0. Therefore, hostile attribution bias and alexithymia completely mediated the relationship between ATs and aggressive behavior in males through three mediating pathways: the mediating effects of (a) hostile attribution bias and (b) alexithymia, and the serial mediating effect of (c) hostile attribution bias and alexithymia. The proportion of indirect mediating effect to total effect (0.16) was 93.75%. Similarly, ATs also influenced aggressive behavior through the complete mediation of hostile attribution bias and alexithymia in females. However, the indirect effects of the other two pathways were all significant except the serial mediated pathway. The total indirect effect value was 0.17, accounting for 65.38% of the total effect (0.26). These results suggested that, unlike the male group, hostile attribution bias and alexithymia play a parallel mediating role in the relationship between ATs and aggressive behavior in females.

Discussion and Implications

Aggressive behavior is one of the common problem behaviors of individuals with ASD, which seriously affects their daily life and social interaction. It has been found that individuals with ASD are more likely to engage in aggressive behavior compared to other populations. However, it is still unclear whether increased aggressive behavior could also be positively predicted by ATs in the general population. Given the SIP model proposed that cognitive and emotional variables in the social information processing would influence the generation of aggressive behavior, the present study chose hostile attribution bias and alexithymia, which are related to ATs, as mediating variables to examine the effect of these variables on aggressive behavior. The findings revealed the internal mechanism of ATs affecting aggressive behavior and gender difference in Chinese college students.

The results of correlation analysis showed that there was a significant positive correlation between ATs, hostile attribution bias, alexithymia, and aggressive behavior, indicating that aggressive behavior was associated with both personality traits, cognition, and emotional variables.[41] In line with previous findings,[30,39] results showed increased hostile attribution bias, alexithymia, and aggressive behavior of individuals with high levels of ATs. After controlling for gender, the total effect of ATs on aggressive behavior was significant, suggesting that ATs positively predict aggressive behavior. Hosie et al found that increased basolateral amygdala excitation in the mouse model of autism, a brain region implicated in aggressive behaviors.[58] Thus, there is a possibility that the altered neural activity in the amygdala caused by ATs contributes to the aggressive behavior we have found in the current study. After adding the mediating variables, however, the direct effect of ATs on aggressive behavior was not significant anymore, suggesting that ATs indirectly predicted aggressive behavior through the completely mediating effect of hostile attribution bias and alexithymia. Although previous studies have found that individuals with ASD often engage in self-harm and aggressive behavior,[15] estimates of their aggressive behavior range from 8% to 68%, indicating that the effect of autistic symptoms on aggressive behavior is not absolute. An earlier study has even shown that the severity of clinical symptoms of ASD itself is not a direct risk factor that contributed to aggressive behavior, and the more severe the social communication and repetitive stereotypical behavior caused by the symptoms, the more likely they engage in aggressive behavior.[19] Similarly, studies have noted that compared with the severity of ASD symptoms, the aggressive behavior of individuals

with ASD is strongly correlated with cognitive function and attention problems.[14] The relationship may be attributed to cultural difference (eg, collectivism culture vs individualism culture). Chinese people often perceive the world as interconnected relationships, reflecting the collectivistic values and Confucian principles prevalent in China. Research has shown that compared to individuals in Western cultures, Chinese individuals tend to prioritize conflict avoidance, negotiation, and relationship maintenance to a greater extent.[59] They may tend to choose indirect ways such as hostility or anger to deal with conflict situations. Based on existing research, this study further illustrated that the cause of aggressive behavior in autistic individuals might be biased information processing and atypical emotion processing patterns triggered by the symptoms,[33,60] rather than the symptoms themselves. Moreover, our results suggested that the relationship between ASD and aggressive behavior also extends to ATs in the general population.

The serial mediation models constructed by this study outlined that the different mediating effect pathways of hostile attribution bias and alexithymia. The results showed that the mediating effect of hostile attribution bias between ATs and aggressive behavior is significant. Consistent with previous findings that hostile attribution bias of autistic individuals affects aggressive behavior.[15] Recent studies have shown that children with ASD cannot effectively encode social information. compared with the control group, they are more likely to attribute hostile intentions to others, to construct and evaluate aggressive responses more positively. Moreover, there was a significant correlation between the information processing deficit and the theory of mind (ToM) ability.[30] The ToM deficit hypothesis of autism,[61] which postulated that the essential reason for the atypical social processing of individuals with ASD is that they cannot understand their own and other's mental states, nor can they recognize and predict the behavior of others based on this information. Moreover, it has been proved that individuals with high levels of ATs are also had ToM deficits.[62] It might indicate that the impairment of ToM in autistic individuals, contributing to more false attributions of other's intentions which in turn affects their behavioral response patterns. In addition, neural mechanism studies have found that the fundamental cause of social cognitive impairment in autistic individuals lies in abnormal functioning of the orbitofrontal/medial temporal circuit, which implicated in the development of ToM and related to how individuals interpret the mental state of others based on the observed clues.[63] A recent study suggested that the brain region associated with hostile attribution bias and aggression is mainly in the prefrontal of the orbitofrontal cortex.[64] Combined with our results, it can be explained that the aggressive behavior of individuals with high ATs is probably due to the lack of ToM caused by the abnormal activity of the orbitofrontal cortex, characterized by difficulty in decoding social information. As a result, they are more likely to make hostile attributions to other people's intentions, which increases the likelihood of aggressive behavior. This hypothesis, however, needs to be further confirmed in future neuroimaging studies.

In addition, the study also found that alexithymia mediated the relationship between ATs and aggressive behavior. Consistent with results from a recent study that found alexithymia was predicted significantly by the level of ATs.[40] Some hypotheses proposed that atypical facial processing seems to be related to alexithymia in autistic individuals,[65] making it difficult to accurately identify the emotion of others. Besides, the general deficit in language features and social skills limited their ability to describe and properly express negative emotions, which may be the possible reason for their increased aggressive response. Empirical studies also found that emotional dysregulation mediated the relationship between alexithymia and aggressive behavior.[66] In other words, the alexithymia in individuals with ATs, characterized by impairments in emotion recognition, emotion expression, and emotion regulation, greatly increased the likelihood of aggressive behavior. Consistent with the general aggression model (GAM) proposed by Anderson and Bushman,[18] which emphasized that the evaluation and decision-making process that determines the final behavior pattern should not only take into account the cognitive process such as hostile attribution, but also the emotion processing and arousal level. Thus, our results are supported by the GAM and previous studies indicating that in addition to hostile attribution bias, abnormal emotional processing like alexithymia in individuals with ATs is also a possible pathway to trigger their aggressive behavior. Furthermore, neural mechanism research of alexithymia has identified altered intrinsic neural activity in the left amygdala.[67] This alteration in neural activity could contribute to aggressive behavior has also been observed in the mice model with ATs.[68] Therefore, we assumed that alexithymia mediated the relationship between ATs and aggressive behavior, which might be caused by the cascading effect of abnormal neural activity in the amygdala.

Notably, hostile attribution bias and alexithymia also played a serial mediating role in the relationship between ATs and aggressive behavior. The results of this study supplemented previous studies on the relationship between hostile

attribution bias and alexithymia, supporting some researchers' hypothesis about the role of cognitive and emotional variables in information processing related to aggressive behavior.[42,43] The present study further revealed the serial mediating effect of hostile attribution bias and alexithymia between ATs and aggressive behavior. It's possible that the distorted perception of hostility increased the difficulty to recognize and understand emotion accurately. In addition, the judgment of hostile intentions made individuals turn to aggressive behavior to eliminate negative emotions and experiences instead of communicating with others, which reflected the positive predictive effect of alexithymia on aggressive behavior. Our results supported the cognitive (attribution)-emotion-action model proposed by Weiner,[49] which suggested that false or biased cognitive attribution style will affect emotional processing and further determine behavioral responses. Existing empirical studies have found that cognitive bias in information processing affects emotion recognition and understanding.[43] Moreover, hostile cognition can influence aggressive behavior through the mediating role of affective empathy.[47] These results indicated that increased hostile attribution bias in individuals with high levels of ATs further hinder accurate recognition and understanding emotions of others, making them more likely to identify other people's emotions as negative and hostile, which in turn reduced the ability to understand and empathize with others and then triggered the aggressive behavior response. According to these results, the rationality of the SIP model and the GAM was supported to a certain extent,[18,41] indicating that personality traits, cognitive and emotional factors as individual's internal state influence the evaluation and decision-making process of behavioral response. The interaction between the three predictive variables, however, needs to be further explored in the future.

The gender difference test found that the serial mediating effect was only significant in the male group, but not in the females. The possible reason is the difference in how they experience and express emotions when facing provocative situations. Previous findings showed that in negative situations, males mainly experienced anger, while females showed sadness. Meanwhile, females adopted more adaptive emotion regulation strategies than males, and less aggressive behaviors were presented.[69] In other words, when individuals of different genders made hostile attributions to the situation, males were more likely to rely on the external situation cues than females because of the anger they experienced and the lack of effective emotion regulation strategies, which makes it difficult for them to effectively identify and express their real emotions and present more aggressive behaviors. However, the influence of hostile attribution bias on emotion recognition and expression in females was weaker than in males because they showed more sadness and used more adaptive emotion regulation strategies. The results of this study indicated that this gender difference in the relationship between cognitive and emotional variables might also exist in individuals with ATs. However, due to the limited research on the gender differences of the mediating variables examined in this study, it remains researchers to further investigate the performance and possible causes of the interaction between cognitive and emotional variables in different genders during the production of aggressive behaviors of autistic individuals.

Certainly, there are some limitations in the present study that remain to improve in future research. First, the study adopted a cross-sectional study design, which could illustrate the directionality of the relationship between variables. However, a causal conclusion cannot be provided in this way. Second, although the common method bias can be ignored from the perspective of procedural control and statistical analysis in the current study, the self-reported questionnaire might have a certain social desirability effect, especially in the measurement of aggressive behavior. Thus, it can be considered to combine with observational data or use experimental designs to measure these variables introduced in this study in the future. Third, the limitation of convenience sampling is the potential for selection bias, as participants may not be representative of the target population. The other is that, the online survey method may introduce self-selection bias, where individuals with stronger opinions or experiences are more motivated to participate, leading to an over-representation of certain viewpoints and potentially distorting the overall findings of our study. It's crucial to consider these biases when interpreting the study's findings and to acknowledge the limitations in generalizing the results to the larger population. Finally, considering the cultural background differences, it is essential to expand research to cross-cultural comparative studies. Such studies may reveal the direct predictive role of ATs on aggressive behavior in Western cultures.

Implications

Based on previous studies, the current study further revealed the internal mechanism of ATs affecting the aggressive behavior of Chinese college students, as well as the potential mediating role of hostile attribution bias and alexithymia on this association and gender difference, which had certain theoretic meaning and practical worth. First, the results provided empirical evidence for the role of cognitive and emotional variables in information processing, which supported the revised SIP model and further illustrated the key factors that affect the aggressive behavior of individuals with ATs. Second, this study had important implications for the intervention and prevention of aggressive behaviors of individuals with ASD and those with high levels of ATs. According to our results, for both populations, the intervention of aggressive behavior should start with basic cognitive and emotional training. Improvement training for hostile attribution bias and alexithymia might truly change the antisocial behavior of individuals with ASD and those with high levels of ATs. For instance, studies have found that emotion recognition training can help individuals improve emotional processing disorders and further reduce aggressive behavior.[70] In addition, self-persuasion or other-persuasion can be adopted to reduce children's hostile attributional bias and their aggressive behavior.[71] We assumed that these training methods could also be tried on autistic individuals and may be equally effective in reducing their aggressive behavior.

Conclusion

The main conclusions of this study are as follows: (1) There was a significant positive correlation between autistic traits, hostile attribution bias, alexithymia, and aggressive behavior; (2) Hostile attribution bias and alexithymia completely mediated the relationship between autistic traits and aggressive behavior, which contained three significant mediating pathways: the separate mediating effects of (a) hostile attribution bias and (b) alexithymia, and the serial mediating effect of (c) hostile attribution bias and alexithymia; (3) Gender differences in mediating effects were only found in the serial mediating effect of hostile attribution bias and alexithymia, which was significant in the male group but not in the female group.

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