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S.I. : EMPATHY IN AUTISM

Autistic Traits and Prosocial Behaviour in the General Population: Test of the Mediating Effects of Trait Empathy and State Empathic Concern

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Abstract

Although the core characteristics associated with autistic traits are impaired social interactions, there are few studies examining how autistic traits translate into prosocial behaviour in daily life. The current study explored the effect of autistic traits on prosocial behaviour and the mediating role of multimodal empathy (trait empathy and state empathic concern). The results showed that autistic traits reduced prosocial behaviour directly and indirectly through complex mediation by multimodal empathy. The findings revealed the internal mechanism of autistic traits impeding prosocial behaviour and expanded our understandings of social behaviour in autism spectrum conditions (ASCs) and autistic traits in the general population. Furthermore, the results have implications for social adaptability interventions for individuals with ASCs and high levels of autistic traits.

Keywords Autism spectrum conditions · Autistic traits · Trait empathy · State empathic concern · Prosocial behaviour

Introduction

Autistic traits (ATs) are considered a set of primary symptoms associated with autism spectrum conditions (ASCs) and are assumed to be continuously distributed in the general population (De Groot and Van Strien 2017). This distribution implies that every single individual's ATs are on a continuum from ASCs to normality. To some extent, ATs in neurotypical and autistic individuals are qualitatively similar, but there is a quantitative difference (Guan and Zhao 2015; Gökçen et al. 2014). Indeed, a growing body of studies have shown that neurotypical individuals with high ATs exhibit characteristics similar to those of individuals with ASCs, such as atypical sensory processing (Robertson and Simmons 2013), poor cognitive flexibility (Gökçen et al. 2014), and reduced sensitivity to social information (Sevgi et al. 2016).

Prosocial behaviour typically refers to intentional acts designed to benefit others and is thought to be important for establishment and maintenance of social relationships, cognitive development, and physical health (Hilbrand et al. 2017). Although the cardinal characteristics associated with ATs are impaired social-cognitive and social-communicative processing, little is known about the extent to which and how prosocial behaviour is influenced by ATs in the general population. Considering the multiple aspects of the facilitating role of prosocial behaviour in individual development, the exploration of the effects of ATs on prosocial behaviour and the underlying mechanisms may help us better understand the nature of the impairments in social interaction specifically in individuals with ASCs and ATs. This examination of the effects of ATs is also helpful for improving the effectiveness of social-adaptive interventions for individuals with ASCs and high ATs.

A few studies have shown that individuals with ASCs behave less prosocially than matched controls, which is shown in behaviours such as donating less (Lin et al. 2012) and helping and sharing less (Meyer et al. 2006). To our knowledge, only two studies have explored the possible disruption of ATs on prosocial behaviour in non-clinical samples (Jameel et al. 2014, 2015). In Jameel et al. (2014)

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study, a series of scenarios involving the participant and an unfamiliar character in need of help were used. Each scenario required a difficult social judgement with respect to balancing the needs of the character against the participant's own interests (e.g., when you are in a hurry to go to a meeting, a person falls down heavily in front of you). Participants were asked to decide on their most likely behaviour among three different choices of social behaviours representing low, medium and high prosocial actions. The results showed that individuals with high levels of ATs were less prosocial. Subsequently, using a similar task but with the clarity of social rules related to helping hidden in situations that were manipulated (clear-cut and ambiguous rules), Jameel et al. (2015) further revealed that it is unlikely that the reduced helping behaviour of individuals with high levels of ATs is due to ATs impeding the acquisition of social knowledge; rather, high-level ATs lead to a lack of socioemotional processing in helping situations. In other words, individuals with high levels of ATs were less sympathetic towards the characters than individuals with low ATs and tended to use rule-based reasoning to explain why they chose to help the character or not.

Empathy, the ability to share and understand the emotions and feelings of others (Trimmer et al. 2017), is considered to be an important motivator of prosocial behaviour and a cardinal impairment related to ATs. It is reasonable that the seminal works mentioned above with clinical and non-clinical samples all emphasized the role of a deficit in empathy associated with ATs in prosocial behaviour in their argument or interpretation of results. To date, there is no empirical study to explore the mechanism of ATs affecting prosocial behaviour. It is likely that empathy potentially mediates the effect of ATs on prosocial behaviour. Nevertheless, empathy is a multifaceted construct composed of affective sharing (AS), empathic concern (EC), and cognitive empathy (CE) components (Oliver et al. 2016). Additionally, empathy can also be distinguished by trait and state (Cuff et al. 2016; Powell and Roberts 2017). Trait empathy is the general tendency to show empathy, whereas state empathy is the transient affective reaction elicited by concrete situations or stimuli (Van der Graaff et al. 2016). Notably, not all facets of empathy contribute to prosocial behaviour and are associated with ATs, which will be discussed in detail. On this account, from a trait-situational perspective, the current study aimed to examine in greater detail the mediating role of multimodal empathy in ATs and prosocial behaviour.

AS reflects the capacity to share or become affectively congruent with others' emotional states at least in valence and intensity and is often used interchangeably with emotional contagion or resonance (Decety and Yoder 2016; Jordan et al. 2016), while EC refers to a specific emotional response to a person in suffering (Stocks et al. 2011), involving a series of feelings including sympathy, compassion, and being moved. For quite some time, prior work did not distinguish between AS and EC, instead using "emotional empathy" to refer to either term (Oliver et al. 2016). In fact, recent studies suggest that these two socioaffective and motivational components have their own distinct characteristics. Sharing in the negative emotions of others who are suffering is usually experienced as self-focused empathic or personal distress (Eisenberg et al. 1989; Lamm et al. 2011; Pérez-Manrique and Gomila 2018). Conversely, EC for others' suffering enables people to experience relatively positive other-oriented emotions related to warmth and concern, reflecting a motivational concern for the welfare of others (Klimecki et al. 2014; Stellar et al. 2015). Thus, in contrast to AS, EC does not need to be isomorphic to others' emotional state but is instead an incongruent appropriate empathic reaction. Moreover, sharing negative emotions activates the brain regions associated with first-hand pain and unpleasant subjective experiences (e.g., the anterior insula and the anterior medial cingulate cortex) (Rainville 2002; Lamm et al. 2011). However, EC is accompanied by activations in the ventral striatum and the medial orbitofrontal cortex that are typically associated with reward and unconditional love (Beauregard et al. 2009; Klimecki et al. 2014). Apparently, then, AS and EC emphasize the emotional experiences are generated during the empathy process, while CE is a series of other-oriented cognitive processes referring to the capacity to understand or infer others' beliefs, intentions and feelings, similar to perspective taking or theory of mind (Tom) (Decety and Yoder 2016). It has been well established that CE is consistently accompanied by activations in regions typically associated with social understanding and judgement, i.e., the medial prefrontal cortex and the superior temporal sulcus (Molenberghs et al. 2016).

Self-reported questionnaires are often used to measure trait empathy, such as the empathy quotient (EQ) (Baron-Cohen and Wheelwright 2004) and the Interpersonal Reactivity Index (IRI) (Davis 1980). Performance-based tasks are often used to probe state empathy. For instance, the eyes test (Baron-Cohen et al. 2001) is widely used to measure state CE, the multifaceted empathy test (MET) (Dziobek et al. 2008) is designed to assess these dimensions simultaneously by separating the empathic reactions in response to emotional pictures, and the empathic concern index is used specifically to measure state EC in a more naturalistic fashion (Batson et al. 2007). These measurements seem to be susceptible to social desirability and the personal ability of introspection or abstract thinking due to these empathy tests being self-reported (Dziobek et al. 2008; Stellar et al. 2015), which potentially limits the purest measurement of empathy. Since there is a relatively objective and correct answer for CE in response to others' mental states, the cognitive component of empathy can be relatively easily distinguished from the emotional components of empathy. However, the

regulation of CE on the emotional components in the empathy process (Decety and Lamm 2006; Smith 2009) makes these offline measurements somewhat harder to get closer to the purer AS and EC. Moreover, AS and EC are frequently both elicited when encountering the suffering of others (Ashar et al. 2017), which further brings challenges in isolating AS and EC from the emotional components of empathy. Using or developing of some objective online indicators is helpful for eliminating the intrinsic limitations of these offline approach and the interference caused by mutual influence among different components of empathy, thus improving the purity of the measurement of empathy.

Empathic affective responsiveness induces various actions of the autonomic nervous system. AS involves automatic mirror imitation and egocentric emotional arousal. Facial EMG activity in the zygomaticus major and the corrugator supercilii muscle can reflect valence matching in the process of AS (Balconi and Canavesio 2013; Van der Graaff et al. 2016), while the sympathetic nervous system activation reflected by increased skin conductance response (SCR) and heart rate (HR) can indicate the degree of egocentric empathic arousal (Bach 2016; Balconi and Bortolotti 2012). EC is preferentially associated with the activity in parasympathetic nervous system reflected by HR deceleration, reduced respiration rate and enhanced respiratory sinus arrhythmia (RSA) (Eisenberg et al. 1989; Stellar et al. 2015). These differential changes in the autonomic nervous system provide some candidate online indexes for the purification of AS and EC. However, previous studies have investigated these links typically in isolation, and it remains unclear whether AS and EC can be accurately and specifically predicted from autonomic nervous system activity.

Although these three components of empathy are relatively dissociable in terms of concept and neural substrate, the different facets of empathy are interrelated and associated with different prosocial behavioural outcomes. Dispositional CE promotes the tendency for concern for others in need by allowing an individual to decode others' situations and adopt their perspective (Jordan et al. 2016; Marjanovic et al. 2012; Rueda et al. 2015). Furthermore, there is no doubt that the state of EC is subject to preexisting dispositional empathy (Cuff et al. 2016; Van der Graaff et al. 2016). For instance, more trait CE and EC are associated with feeling moved more frequently (Zickfeld et al. 2017) or experiencing stronger feelings of compassion when witnessing others' suffering (Davis 1983; Eerola et al. 2016). In terms of the empathy-prosocial association, trait CE and trait EC motivate prosocial behaviour (FeldmanHall et al. 2015; Jordan et al. 2016; Marjanovic et al. 2012). Thus, these sociocognitive and socioemotional tendencies are regarded as two important prosocial traits (Marjanovic et al. 2012), while state EC is the situational antecedent of prosocial behaviour (Batson et al. 2007; Ding and Na 2015). In contrast, sharing the emotions of others in a negative social situation leads to personal distress, which has been associated with motivation to relieve one's own discomfort and stress and therefore does not promote and can even hinder the generation of prosocial behaviour (Jordan et al. 2016). It can be seen from combining the interrelationships among the different facets of trait empathy, trait-state associations of empathy and the empathy-prosocial link that state EC is a proximate antecedent of prosocial behaviour, and dispositional empathy is a distal idiosyncratic antecedent of prosocial behaviour. Furthermore, the trait antecedent may affect prosocial behaviour by promoting state EC.

Studies based on trait tendency, as measured by the EQ (Baron-Cohen and Wheelwright 2004) and the perspective taking (PT) subscale of the IRI (Rogers et al. 2007; Rueda et al. 2015), and on task performance, as measured by the eyes test (Baron-Cohen et al. 2001; Rueda et al. 2015) and the MET (Dziobek et al. 2008), have consistently found ASC-specific deficits in CE. In accordance with these findings, in the general population, a growing body of research based on both trait tendency and task performance measurements has revealed that the levels of ATs, as measured by the autism spectrum quotient (AQ; Baron-Cohen et al. 2001), are inversely correlated with CE (Aaron et al. 2015; Baron-Cohen et al. 2001; Gökçen et al. 2014) or that high levels of ATs are associated with weak CE (Lockwood et al. 2013; Oliver et al. 2016).

Some studies have found that ASCs are weakly associated with the general tendency to have EC towards a person in need (Dziobek et al. 2008; Trimmer et al. 2017), although this weak tendency is not always the case (Rueda et al. 2015). Similarly, studies from non-clinical samples have also found a significant negative correlation between ATs and dispositional EC (Aaron et al. 2015). However, less attention has been paid to examining whether autistic individuals perceive a lower intensity of state EC or whether there is a negative correlation between ATs and state EC in the general population. Studies using the MET did not find a link between ASCs or ATs and reduced state EC (Dziobek et al. 2008; Oliver et al. 2016). It is worth noting that the state EC measured by the MET is an overall feeling of concern; thus, it is not enough to highlight the widely recognized definition of state EC that includes several specific other-oriented emotions. Conversely, a recent study has revealed that toddlers with ASCs have less EC for parental distress than those with no ASCs (Campbell et al. 2017). However, this study does not effectively distinguish between EC and AS. To our knowledge, only one study using helping scenarios found that individuals with high versus low ATs reported less sympathy for characters in need (Jameel et al. 2015). Unfortunately, this study used only one affective item (sympathy). EC reflects the extent to which an individual cares for the welfare of others (Jordan et al. 2016). Therefore, EC

can be regarded as a specific embodiment of general social motivation or preference in a helping situation. Additionally, it has been well established that ASCs are associated with reduced social preferences or motivation (Burnside et al. 2017; Lin et al. 2012). Thus, we argue that ASCs or ATs are more likely to be associated with reduced trait and state EC, although the results of previous studies are controversial.

Whether or not AS is impaired in ASCs or associated with ATs is a complex issue. Several experimental studies showed that individuals with ASCs have delayed or absent automated mimicry and arousal in the process of emotional contagion (Mathersul et al. 2013; Oberman et al. 2009), indicating impaired AS. However, the more common experimental result is that autistic individuals have a preserved ability to affectively resonate with other people's emotions (Hadjikhani et al. 2014; Trimmer et al. 2017) or that ATs are not associated with reduced AS (Lockwood et al. 2013; Oliver et al. 2016). The different regulatory effects of attention on the AS process caused by differences in experimental paradigms is likely to be the cause of these confusing disputes (Fan et al. 2014). According to the empathy imbalance hypothesis (EIH) (Smith 2009), ASCs are associated with a surfeit of AS, and the "impaired AS" in autistic individuals in the corresponding task is actually the embodiment of heightened AS. Namely, the enhanced AS urges those individuals to use avoidant patterns of attention to restrict empathic arousal in order to reduce the sense of discomfort caused by excessive arousal. In line with the EIH, ASCs and ATs are associated with enhanced trait PD in response to others' suffering, as measured by the PD subscale of the IRI (Aaron et al. 2015; Rogers et al. 2007).

In summary, although a few previous studies have revealed that ATs may impede the generation of prosocial behaviour in the general population, the internal mechanism of this negative influence is not clear. It could be deduced from our detailed literature review that empathy may potentially mediate the effect of ATs on prosocial behaviour. Based on the multidimensional features of empathy, from a trait-state perspective, the present study aimed to comprehensively examine how ATs transfers through trait empathy to state EC, thereby negatively affecting prosocial behaviour.

We measured empathy dispositions and ATs using the IRI and the AQ. Similar to previous studies (Ashar et al. 2017; Ding and Na 2015), a more ecological scenario describing a character suffering from serious diseases was used to induce state EC, and five emotional words frequently used in previous studies (Batson et al. 2007) were used to measure state EC for this character. Subsequently, an economic game known as the empathic dictator game (DG) was used to assess the prosocial helping behaviour towards this character. The standard DG has been widely used to investigate the general altruistic, prosocial and sharing behaviours in normal and ASC populations (Hartley and Fisher 2018; Paulus and Rosal-Grifoll 2016). In the standard DG, a 'dictator' (the participant) can freely distribute a given amount of money to himself and a recipient in a one-shot, anonymous situation. Edele et al. (2013) found that trait EC is associated with a more altruistic apportionment to the anonymous recipient. More importantly, in an empathic DG, an allocation decision is preceded by a state EC induction, and the recipient is the suffering character. State EC can also significantly predict money-helping behaviour towards a suffering character (Ding and Na 2015), or the amount of apportionment in an empathic DG is significantly greater than that in a standard DG and a control DG (Klimecki et al. 2016). These studies strongly revealed participants' EC towards the suffering recipient to cause more prosocial allocations. In addition, the decision making under this economic context is less affected by social desirability due to the economic decision being directly related to individuals' personal interests. Thus, the allocation in empathic DG more genuinely reflects the level of prosocial behaviour than that indicated by directly asking about participants' willingness to help.

Based on our review of the relationships between the variables of interest, we predict that ATs are negatively correlated with dispositional CE, dispositional EC, state EC and prosocial behaviour, as manifested by the amount of money allocated to the suffering character in the empathic DG. However, we predict that ATs are positively correlated with dispositional PD and that prosocial behaviour is positively correlated with trait EC, trait CE and state EC but is not or is even negatively correlated with dispositional PD. State EC is predicted to be positively correlated with trait EC and trait CE, and trait EC is predicted to be positively correlated with trait CE. We also predict that multimodal empathy mediates the relationship between ATs and prosocial behaviour. We further assume that there are likely three subtypes of mediating mechanisms in the overall mediating mechanism of multimodal empathy. Namely, the mediating mechanism of the single facet of multimodal empathy, the chain-mediating mechanism of multimodal empathy from the trait-to-trait level (e.g., from trait CE to trait EC), and the chain-mediating mechanism of multimodal empathy from the trait-to-state level (e.g., from trait CE to state EC).

Methods

Participants

This study was approved by the Ethics Committee of the Department of Psychology at Shanghai Normal University. A total of 590 Chinese Han college students with no known diagnosis of neurological disease, psychiatric problems, or head injury were surveyed. After the questionnaires with incomplete answers and obvious repeating

answer patterns were eliminated (Chang and Chen 2015), there were 579 effective participants (249 males, 330 females, average age = 20.10 years, $SD = 1.58$, range 18–26), including 123 (34 males, 89 females) students of pedagogy, 109 (38 males, 71 women) students of management, 121 (males 31, 90 females) students of psychology, 70 (50 males, 20 females) students of mathematics, 93 (50 males, 43 females) students of biology, and 63 (46 males, 17 females) students of engineering.

Materials and Measures

Mandarin Autism Spectrum Quotient

The Mandarin AQ is a reliable instrument for quantifying ATs in both clinical and non-clinical samples in mainland China, and it has been shown to have promising psychometric properties based on samples of 1037 parents (mean age: 35.51 ± 4.56 years; mean AQ: 110.4 ± 9.22) of children with ASCs, 1040 parents (mean age: 35.86 ± 4.48 years; mean AQ: 105.6 ± 10.54) of typically developing children, and 32 participants with ASCs (mean age: 19.41 ± 3.88 years; mean AQ: 133.40 ± 10.01) (Zhang et al. 2016). Consistent with the initial questionnaire (Baron-Cohen et al. 2001), the Mandarin AQ includes 50 items covering five areas: imagination, attention switching, attention to detail, social skills, and communication. It uses a continuous (4-point Likert) scale (ranging from 1 to 4 for items portraying autistic features). A high AQ score indicates a high autistic load. The internal reliability of sub-dimensions had alpha levels ranging from 0.62 to 0.77 and satisfactory test–retest reliability ranging from 0.62 to 0.76 (Zhang et al. 2016). In this study, the internal reliability of sub-dimensions had alpha levels ranging from 0.54 to 0.75; the overall mean AQ score was 117.91 ± 8.44; the mean AQ score for males was 120.20 ± 9.40, with a range of 80–152; and the mean AQ score for females was 116.18 ± 7.20, with a range of 91–132.

Trait Empathy

In accordance with previous studies (Decety and Yoder 2016; Rueda et al. 2015), we used the EC, PT, and PD subscales from the IRI to measure the trait EC, dispositional CE and trait AS, respectively. Each item is answered on a 5-point Likert-type scale ranging from "not true of me at all" to "frequently true of me.". The IRI has demonstrated good test–retest reliability and convergent validity (Davis 1980). The reliability of each subscale obtained in this sample was $\alpha = 0.66$ for PT, $\alpha = 0.70$ for EC and $\alpha = 0.71$ for PD.

State Empathic Concern Index

We used the version of the State Empathic Concern Index that was suitable for a Chinese context, developed by Ding and Na (2015) and based on Batson et al. (2007) study. The State Empathic Concern Index was composed of a story involving a girl suffering from a disease and five emotional words. The story was as follows:

> Xiaobei, a passionate and beautiful eighteen-year-old freshman, came to our university from her hometown in a remote mountain area. She is full of longing for the future. Unfortunately, she was recently diagnosed with a rare disease, haemophagocytic syndrome, and is dying. However, she is still struggling with the disease. Her situation immediately aroused the attention of all schoolteachers and students, and many people did their best to help her.

After reading the disease-related situation story, participants were asked to complete the State Empathic Concern Index, on which they indicated the degree to which they felt each of 5 emotions (including sympathetic, compassionate, being moved, worried, and concerned) towards Xiaobei (1 = not at all, 7 = extremely). A high score indicates a more intense empathic response towards Xiaobei. In this study, the Cronbach's α coefficient of the State Empathic Concern Index was 0.80.

Empathic DG

When the participants completed the State Empathic Concern Index, they were told to play a game with Xiaobei. The instructions were as follows:

> There are two roles, A and B, in the game. If you randomly play the role of A, then Xiaobei plays the role of B to match you. The rule of the game is that the person who randomly plays the role of A needs to allocate some money (X Chinese Yuan) to B, and ultimately, B gets three times as much money as you gave him or her (3X Chinese Yuan). If you were now A and had 2000 Chinese Yuan in total, how much would you allocate to Xiaobei (it can be any amount from 0 to 2000)?

Procedure

The questionnaires were administered to classes of 25–40 students for one of several data collection times. Participants were informed about the voluntary nature of the study, and they were guaranteed anonymity of their responses and confidentiality of the data and obtained small gifts (a ballpoint pen of 2.5 Chinese yuan) in exchange for participating.

During each time of data collection, participants were told to put the questionnaire on the corner of the table when they finished. Subsequently, 2–3 assistants quickly previewed the questionnaire to check whether there were any omissions. If there were any omissions, participants were asked to fill in the answers. Eventually the questionnaires were collected on the spot, and students were appreciated for their participation.

Statistical Analysis

Data analysis was conducted using SPSS Statistics 19.0 and the PROCESS macro for SPSS. Gender differences were consistently found in multimodal empathy (Barraza and Zak 2009), prosocial behaviour (Eagly 2009) and ATs (Baron-Cohen et al. 2001); thus, an independent samples t-test was used to analyse the possible gender differences in these variables using the current data. Based on our hypothesis, Pearson correlations were used to analyse the bivariate correlations between variables of interest. In the test of the mediating effect, the bootstrap procedure performs better than the causal steps approach and the Sobel test in terms of validity and statistical power (Hayes 2015). If the 95% bootstrap confidence interval for the indirect effect is entirely above or below zero, then the indirect effect is significant; otherwise, the opposite is true (for more details, see also Hayes and Rockwood 2017). Therefore, the bootstrap method in the PROCESS macro for SPSS was used to test the statistical significance of the indirect effects in this study.

Results

Common Method Bias Test

Since this study used a self-report form to collect data, the results may be influenced by common method bias. We controlled for common method bias though procedural remedies and statistical remedy analysis. First, the principles of "no right or wrong" and anonymity were emphasized, and the question order was counterbalanced across the questionnaire survey. Second, using Harman's single-factor test (Podsakoff et al. 2003), all of the variables were included in an exploratory factor analysis to determine common method variance. The results showed that the data were suitable for factor analysis ($KMO = 0.80$, Bartlett = 13,919, $p < 0.001$), and the first factor under the unrotated condition explained 14.56% of the total variance, or less than 40%, suggesting there was no significant common method bias (Podsakoff et al. 2003).

Gender Differences Among Variables

Gender differences among variables are detailed in Table 1.

Table 1 Gender differences among variables

Variables	Gender	*M*	*SD*	*t*	*d*
1. Autistic traits	Male	120.20	9.40	5.82**	0.26
	Female	116.18	7.20		
2. Trait CE	Male	15.90	3.44	−5.75**	0.48
	Female	17.54	3.37		
3. Trait EC	Male	15.54	3.32	−7.54**	0.59
	Female	17.60	3.60		
4. Trait PD	Male	15.03	3.43	−5.28**	0.46
	Female	16.61	3.45		
4. State EC	Male	16.05	4.16	−5.18**	0.43
	Female	17.75	3.68		
5. Prosocial behaviour	Male	632.21	519.34	−3.13**	0.26
	Female	763.98	486.71		

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$. These symbols also apply to the tables below

The mean scores for trait CE, trait EC, trait PD, state EC and prosocial behaviour were significantly higher in females than in males. In addition, males showed higher levels of ATs than females.

Correlations

Correlational analyses are detailed in Table 2.

Except for the correlation coefficients between trait PD and trait CE, state EC, and prosocial behaviour, there were significant correlations between other variables.

Mediation Analysis

Based on our assumptions and the results of the correlation analysis, we used model 6 in the PROCESS program to test the mediating effects of multimodal empathy between ATs and prosocial behaviour. The scores on all variables in the path analysis were converted to z-scores. After controlling for the effect of gender, the regression coefficients of each path were significant (detailed in Fig. 1). The direct negative prediction effect of ATs on prosocial behaviour was significant. Therefore, the seven sub-models contained in the whole mechanism model were all partial mediating models. Furthermore, bootstrap estimates (based on 5000 bootstrap samples) indicated that the mediator effects of all sub-models and the whole model were significant. In other words, ATs not only directly impede the production of prosocial behaviour but also further reduce prosocial behaviour through the mediating effect of multimodal empathy. The point estimate of each indirect effect, the 95% confidence interval of each point estimation, and the proportions of the indirect effect to the total effect for each mediation model and the total mediation model are shown in Table 3.

Table 2 Bivariate correlations between variables of interest

Variables	*M*	*SD*	1	2	3	4	5	6
1. Autistic traits	117.91	8.44	1					
2. Trait EC	16.72	3.40	−0.202**	1				
3. Trait PD	15.93	3.64	0.095*	0.237**	1			
4. Trait CE	16.84	3.50	−0.199**	0.366**	0.017	1		
5. State EC	17.02	4.00	−0.199**	0.324**	0.025	0.244**	1	
6. Prosocial behaviour	707.31	504.81	−0.215**	0.236**	−0.024	0.259**	0.244**	1

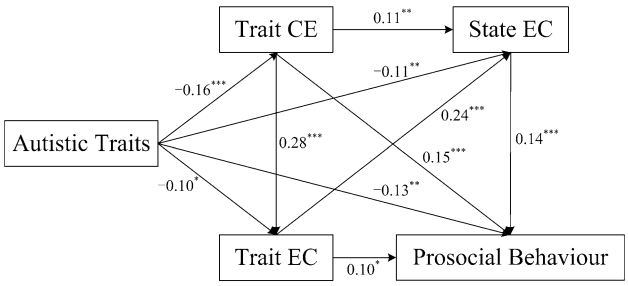

Fig. 1 The regression coefficient of each path. Microsoft Office Visio 2007 was used to create this path graph

Discussion

Although the core characteristic associated with ATs is impaired social interaction, there are few studies examining the possible negative influence of ATs on prosocial behaviour or the internal mechanisms underlying this influence in the general population. In addition, the study of ATs is primarily carried out in Western cultures, with less attention to the possible cultural differences in ATs and cognitive or behavioural characteristics related to ATs. Based on the characteristics of multimodal empathy related to ATs and the contribution of the different dimensions of empathy to prosocial behaviour, from a trait-situation perspective, and using a disease-related helping scenario and empathic DG to measure prosocial behaviour more effectively and ecologically, the present study systematically revealed how autism traits translate into prosocial behaviour by influencing multimodal empathy under Eastern cultural context.

The AQ scores in our samples were significantly higher than those reported by Zhang et al. (2016). The average age of the participants in our study is nearly 15 years younger than that of the participants in the study by Zhang et al. Thus, this difference in AQ is reasonable, because social skills and communication grow with social interaction in the normal population (Zhao and Guan 2015). Future research based on longitudinal designs is required to detail the developmental characteristics of ATs. To facilitate a comparison between AQ scores in our study and in studies from Western countries, we recalculated the AQ scores using the original scoring method (Baron-Cohen et al. 2001), and the overall mean AQ score was 21.05 (range 8–35), which is significantly larger than the mean score of 16.94 reported by a recent meta-analysis based on 6934 non-clinical English-speaking participants (Ruzich et al. 2015). Nevertheless, our results are extremely similar to those obtained in other countries with Eastern cultures (the overall mean AQ score for Japan was 20.70 or 22.15, that for Malaysia was 21.65, and that for India was 21.22; the mean ages of the participants in these studies were similar to those of the participants in our study) (Freeth et al. 2013; Kunihira et al. 2006; Wakabayashi et al. 2006). Meanwhile, the overall AQ scores (17.23, 17.60) of the UK samples included in the studies by Freeth et al. (2013) and Wakabayashi et al. (2006) were very close to the AQ score reported in the meta-analysis by Ruzich et al. (2015). This finding showed that AT levels

Table 3 Mediating effects of each sub-model and total model

Model	Ratio (%)	Effect	SE	BootLLCI	BootULCI
Total	31.60	−0.061	0.0146	−0.094	−0.037
Mod 1. ATs→T-CE→PB	12.43	−0.024	0.0095	−0.050	−0.010
Mod 2. ATs→S-EC→PB	8.04	−0.016	0.0066	−0.032	−0.010
Mod 3. ATs→T-EC→PB	5.00	−0.010	0.0073	−0.031	−0.0001
Mod 4. ATs→T-CE→T-EC→PB	2.42	−0.005	0.0026	−0.011	−0.001
Mod 5. ATs→T-EC→S-EC→PB	2.00	−0.003	0.0022	−0.010	−0.0002
Mod 6. ATs→T-CE→S-EC→PB	1.33	−0.003	0.0014	−0.007	−0.001
Mod 7. ATs→T-CE→T-EC→S-EC→PB	0.80	−0.002	0.0007	−0.004	−0.001

ATs autistic traits, *T* trait, *S* state, *PB* prosocial behaviour

were reported to a greater extent in Eastern cultures than in Western cultures. This cultural difference in AT levels seems to be counterintuitive. Western cultures typically endorse higher levels of individualism, emphasizing self-direction, autonomy and uniqueness of the self (Cheon et al. 2013). Conversely, Eastern cultures generally endorse collectivism, emphasizing interdependence, harmony and connectedness of the self to others (Varnum et al. 2010). In addition individuals from Eastern cultures tend to be field-dependent in the process of attention and cognition, whereas individuals from Western cultures tend to be field-independent (McKone et al. 2010). These differences in social orientation and cognitive styles between Eastern and Western cultures seem to suggest that there should be higher AQ scores in Western cultures than in Eastern cultures. Freeth et al. (2013) suggested that this counterintuitive difference is primarily due to cultural differences in emotional expression and social skills. More cross-cultural studies are needed in the future to examine whether the cultural differences in ATs are rooted in a certain biological basis.

The higher levels of ATs in males found in the current study replicated findings reported in previous studies (Baron-Cohen et al. 2001; Freeth et al. 2013). This gender difference may stem from the more autistic-like behaviours caused by the higher levels of foetal testosterone (FT) in males (Auyeung et al. 2010) and the uneven negative influence of genetic variation associated with ASCs on gender (Werling and Geschwind 2013). In addition, in line with previous studies (Barraza and Zak 2009; Ding and Na 2015), our findings revealed that females have stronger tendencies than males in multimodal empathy. The higher levels of FT in males appear to hinder their CE (Auyeung et al. 2013). In addition, study-based administrations showed that levels of oxytocin are associated with increased EC and CE (Auyeung et al. 2013; Palgi et al. 2014), while females have greater oxytocin release than males during the empathy process (Barraza and Zak 2009). Furthermore, males and females form different gender-role orientations, as required by their social structure in the process of socialization, which further contributes the gender difference in empathy. For instance, females are encouraged to care more for others' feelings and needs (Lam et al. 2012), which is directly related to empathy. However, males are more concerned about equity and justice; this emphasis on universality rather than the needs of specific others is unlikely to foster empathy (Karniol et al. 2003). These gender differences in ATs and empathy could be understood jointly in the framework of the empathizing-systemizing (E-S) theory (Baron-Cohen 2002). The E-S theory assumes that human gender differences are primarily embodied in the two domains of empathizing and systemizing; furthermore, females have greater empathizing than males, while males have greater systemizing than females. This theory further suggests that the typical male brain is characterized by $S > E$, and ASCs are the result of the over-development of the male brain ($S \gg E$) (Baron-Cohen 2009). Based on the nature of the continuity distribution of ATs, ATs appear to fundamentally reflect the extent to which S is greater than E (Guan and Zhao 2015), which clearly explains the gender differences in ATs.

Our results also revealed a prosocial advantage reflected by more monetary apportionment to suffering others among females. However, there is no universal "more helpful sex"; rather, the gender advantage of prosocial behaviour emerges when the type of prosocial behaviour is in line with the specific sex role (Eagly 2009). According to the social role theory (Diekman and Clark 2015; Eagly 2009), males have more advantages than females in the type of prosocial behaviour related to physical risk or chivalry, while females have more advantages than males in concern and caring for socially vulnerable individuals. Obviously, our helping situation is more compatible with the prosocial advantages of females. In combining these gender differences in ATs and multimodal empathy and the interrelationships between these variables (discussed below), gender differences in prosocial behaviour may reflect how gender differences in empathizing and systemizing affect the final behavioural output in specific contexts.

No significant correlation was found between trait PD and trait CE, illustrating that AS and CE are independent (Lamm et al. 2011; Molenberghs et al. 2016). Although there was a significant positive correlation between trait PD and trait EC, no significant correlation was found between trait PD and situational EC, suggesting that the ability to resonate with others' emotions does not lead individuals to feel more other-focused empathic feelings for a person in need. This result further illustrated that AS and EC, the two emotional components of empathy, are at least partially distinct (Jordan et al. 2016; Klimecki et al. 2014). In addition, trait EC and trait CE significantly predicted state EC, suggesting that these mature or high-order empathic dispositions (Aaron et al. 2015) are the idiosyncratic antecedents of state EC. Finally, consistent with the findings of previous studies (Christ et al. 2016; Jordan et al. 2016; Stocks et al. 2011), we found that individual dispositions in trait CE predicted scores on trait EC. CE may be a precursor of other forms of empathy (Powell and Roberts 2017), and it appears that those who put themselves into the mental shoes of another person to understand what she or he feels and thinks are more likely to care about the welfare of others.

Our results showed that ATs are associated with enhanced trait PD but reduced trait CE. Trait PD reflects dispositional AS (Decety and Yoder 2016; FeldmanHall et al. 2015; Singer and Klimecki 2014) or a narrower sense of emotional empathy (Jordan et al. 2016) to a certain extent. Therefore, the positive correlation between ATs and trait PD suggested that higher levels of ATs are related to higher levels of

aversive arousal in response to others' suffering or a higher tendency to resonate with others' negative emotions, which is consistent with the findings of previous studies based on trait tendency (Aaron et al. 2015; Dziobek et al. 2008) and self-statements from individuals with ASCs (Smith 2009). Our finding that ATs predicted reduced trait CE is consistent with previous literature demonstrating that high levels of ATs or ASCs are generally related to difficulties in understanding others' minds (Baron-Cohen and Wheelwright 2004; Lockwood et al. 2013; Rueda et al. 2015).

EC relates to the motivation to care for the welfare of others (Jordan et al. 2016; Oliver et al. 2016). Trait EC reflects the general tendency of this socioemotive element, while state EC is the embodiment of trait EC in a situation and involves specific other-related feelings. In line with previous studies based on trait measurement (Aaron et al. 2015), our findings showed that ATs predicted reduced dispositional EC, suggesting that ATs are associated with limited general socioemotive motivation to care about others' misfortunes. Compared with previous studies (Campbell et al. 2017; Jameel et al. 2015; Oliver et al. 2016), the current study directly examined the relationship between state EC and ATs and found that ATs predicted reduced intensity of perceived other-oriented empathy when faced with another's plight. Taken together, these patterns may reflect a general association between ATs and the lack of motivational preference for complex social stimuli or situations.

It can be seen from the aforementioned elaboration that ATs are associated with enhanced self-focused AS but reduced other-oriented EC and CE. An important issue is why there is such an association. These components of empathy are relative separation and complementary systems, which allows them able to regulate each other (Smith 2006, 2009). In a balanced empathy system, CE provides a core mechanism for the attenuation of empathic arousal through other-oriented information processing and executive control (Decety and Lamm 2006; Smith 2009). Moreover, recent studies have revealed that self-focused empathic arousal and other-oriented EC are more likely to rely on antagonistic affective systems (Klimecki et al. 2014; Stellar et al. 2015); for example, AS and EC are preferentially associated with the sympathetic and parasympathetic systems, respectively. Taken together, CE and EC could turn aversive arousal states caused by AS into relatively calm states and strengthen positive affect (Decety and Lamm 2006; Klimecki et al. 2014; Stellar et al. 2015), and eventually empathy is directed in a more prosocial direction. Thus, as Klimecki et al. (2014) have pointed out, these higher-order empathy components are more similar to a type of emotion regulation strategy on the basis of not neglecting the presence of distress or changing the reality of the plight. In light of the fact that ASCs and ATs are associated with reduced CE and EC, we suggested that the limited regulation of these higher-order empathy components on AS leads to enhanced self-focused empathic arousal, no matter whether or not the AS per se is excessive or normal.

Consistent with the findings of previous studies (Batson et al. 2007; Christ et al. 2016; Klimecki et al. 2016), our findings showed that trait CE and trait and state EC predict increased prosocial behaviour. Those findings suggested other-focused empathic tendencies in cognitive and emotional facets, and the instant feelings of empathic other-oriented concern are the dispositional and situational antecedents of prosocial behaviour. Conversely, there is a negative but non-significant correlation between trait PD and monetary help, providing evidence that self-sacrifice to help others in suffering is not driven by resonating with the negative emotions of others (Jordan et al. 2016). More importantly, our results showed that ATs predicted reduced prosocial behaviour, consistent with previous findings revealing that individuals with ASCs or high ATs act less prosocially (Izuma et al. 2011; Jameel et al. 2014, 2015). As per the findings mentioned in the previous and current studies, trait EC, trait CE and state EC are not only the precursors of prosocial behaviour but also the impaired aspects associated with ATs. Although some researchers have inferred that the impaired empathy of individuals with ASCs or high ATs causes their reduced prosocial behaviour, there have been no studies directly examining the role of multimodal empathy between impeded prosocial behaviour and ATs. These results are the first known findings that delineate a complex mediating mechanism between ATs and prosocial behaviours through trait empathy and state EC.

More concretely, from the perspective of empathic dispositions, our findings revealed three mediating models (Mod 1, Mod 3 and Mod 4), and the indirect effects in these models explained 19.85% of the total effect and 62.82% of the total indirect effect. Namely, ATs not only directly impede prosocial behaviour but also reduce prosocial behaviour by restricting the general tendency to care for the welfare of others (Mod 3) and hindering the comprehension of the character's mental states (Mod 1), such as Xiaobei's desire for a good life, struggle against illness, and insistence on faith. Further, ATs restrict the general tendency to care for another's feelings by hindering a cognitive understanding of another's mind, eventually leading to less prosocial behaviour (Mod 4). From the perspective of state EC, ATs also reduce prosocial behaviour by depressing individuals' received intensity of immediate empathic feelings (Mod 2), and this mediating model explains 8% of the total effect and 25.32% of the total indirect effect. From the perspective of the proportion of trait empathy to state empathy, three mediating models (Mod 5, Mod 6 and Mod 7) that explain 4.13% of the total effect and 13.07% of the total indirect effect were found. Namely, ATs eventually lead to reduced prosocial behaviour by

reducing trait CE and trait EC and then leading to less state EC, respectively (Mod 5 and Mod 6). Furthermore, ATs reduce prosocial behaviour through a more complex chain mediator of trait CE, trait EC and state EC (mod 7).

Although our findings have systematically revealed the complicated mediating roles of multimodal empathy between ATs and prosocial behaviour from the three levels of preexisting empathic tendencies, state EC and from trait to state, the total mediating effects of multimodal empathy explained 31.60% of the total variance. This finding suggested that prosocial behaviour is impeded mainly by the direct influence of ATs, or there exist other mediators between ATs and prosocial behaviour.

Appropriate social behaviour in a situation requires the navigation of corresponding social knowledge (Jameel et al. 2015), and this knowledge is acquired through practice in social interactions and social implicit learning. It has been proposed that individuals with ASCs store less social knowledge than typical developing individuals (Channon et al. 2001). With respect to the subclinical characteristics, as the items of the AQ show, such as "I would rather go to a library than to a party", ATs are associated with reduced frequency of social interaction. Moreover, a recent study by Hudson et al. (2012) revealed that ATs are also related to an impaired ability to acquire social knowledge implicitly. Thus, it is likely that ATs impeded the representation of social knowledge, resulting in reduced prosocial behaviour.

It should be noted that this hidden social knowledge in helping situations used in previous studies (Jameel et al. 2014, 2015) and in our studies is relatively simple and unitary (e.g., helping vulnerable groups is a universal social norm). Based on Jameel et al. (2015) findings, there were no group differences in ATs found on ratings of character expectations that were indirectly used to assess acquired social knowledge. It is possible that ATs are not enough to influence the acquisition of this simple knowledge related to helping. Nevertheless, this intact social knowledge, as determined by explicit measurement in individuals with high-level ATs unable to illustrate the ATs, does not affect the whole mapping between social knowledge and the output of prosocial behaviour. Some studies have suggested that ASCs or ATs are generally associated with limited spontaneous social behaviour or cognitive processes, which may be caused by deficient social motivation. For instance, individuals with ASCs have intact explicit ToM but impaired implicit ToM (Burnside et al. 2017; Schuwerk et al. 2015). Similarly, individuals with high-level ATs have less spontaneous use of knowledge of social cues to improve performance (Sevgi et al. 2016). Another possibility, therefore, is that ATs limit the individual's spontaneous or motivational use of social knowledge related to helping, resulting in less prosocial behaviour.

Certainly, we must address the limitations of the current study. As previously discussed, the multimodal empathy measured by subjective reports is likely to restrict the purity of the measured empathy due to their inherent limitations (Dziobek et al. 2008; Oliver et al. 2016). In addition, because the empathic DG we used is one-short, the measurement of prosocial behaviour may still be potentially affected by random effects, although our large sample size can effectively eliminate this effect. Future experimental designs based on multi-scenario empathic DG and combined with online physiological indexes are required to consolidate the causal models revealed in our path analysis.

This study was conducted in the framework of empathy-prosocial associations. Therefore, the patterns found in our study may not be generalized to other prosocial behaviours unrelated to empathic responses, e.g., giving and sharing, as these prosocial behaviours are preferentially associated with the perception of fairness (Trommsdorff et al. 2007). The applicability of our results is also likely to be constrained by situational types. According to Weiner's attribution-emotion-help model (Pilati et al. 2015; Weiner 2012), EC for and helping a person in need are affected by an observer's attribution for the causes of the person's plight; if the cause is considered controllable by the person, then this person is judged to be responsible for his or hers situation, thereby triggering anger and reducing EC and subsequent prosocial behaviour. Conversely, EC is generated when observers perceive that the plight is uncontrollable for the person in need, thereby contributing to prosocial helping. The disease-related scenario used in this study pertains to the latter; thus, the models revealed in this study are not likely to be applicable to other disease-helping situations that are generally considered to be controllable, e.g., the helping situation associated with HIV infection through drug abuse (Zhang et al. 2013).

The current study was conducted in China, a more collectivist society. Thus, the universality of the patterns found in our study may be influenced by social cultures. We can infer from existing studies and from our study that the levels of ATs are higher in Eastern collectivist cultures than in Western individualist cultures. Similar to the results of experimental studies conducted in Western cultures (Jameel et al. 2014, 2015), although our findings also revealed a robust impeding effect of ATs on prosocial behaviour, because of the methodological differences, it is not clear to what extent this negative influence is equivalent across different cultures. In addition, although the empathy-prosocial association was found consistently in both Eastern (Ding and Na 2015) and Western cultures (Batson et al. 2007; Klimecki et al. 2016), social cultures may regulate the relationships between multimodal empathy and prosocial behaviours. Concerning the feelings and perspectives of others seems to be a useful strategy for achieving social goals of maintaining harmony and

relationships prevailing in collectivist cultures, concerning or recognizing one's own feelings and experiences in social interaction seems to be a more useful processing strategy for achieving the social goals of being unique and autonomy prevalent in individualism cultures (Cohen et al. 2007; Markus and Kitayama 1991). A more effective empathy process needs not only to focus on other people's feelings and mental states, but also to restrain the egocentric perspectives and affective states (Lin et al. 2010). These cultural differences in self-oriented and other-oriented may directly affect individual's empathy for others in suffering (Cheon et al. 2013), and then regulate the relationship between empathy and prosocial-helping. Furthermore, social culture is likely to affect prosocial behaviour by influencing personal values. The self-transcendence value and self-enhancement value are positively correlated and negatively related to prosocial behaviour, respectively (Daniel et al. 2015). Compared to individualistic cultures, the level of self-enhancement in collectivist cultures is lower, but the level of self-transcendence is higher (Le and Levenson 2005; Kurman 2003). Therefore, the overall variations in personal values caused by social culture may also be the cause of cultural differences in prosocial behaviour. Taken together, the patterns found in this study may not be cross-cultural equivalence, the relationships among these variables (e.g., ATs–prosocial behaviour and empathy–prosocial behaviour) appear to be regulated by social cultures.

In conclusion, although prior research suggests that high levels of ATs are associated with less prosocial behaviour, the specific mechanism of this negative impact is not clear. The present findings extend those findings and suggest that ATs not only directly reduce prosocial behaviour but also further decrease prosocial behaviour indirectly through the complex mediation of multimodal empathy. Future work is required to further investigate the cross-contextual and cross-cultural applicability of the patterns found in the current study.

Author Contributions The individual contributions of authors to the manuscript: XZ and XL conceived of the study, participated in its design and coordination and performed the statistical analysis and drafted the manuscript; YS performed the measurement and participated in the interpretation of the data; WS conceived of the study, and participated in its design and coordination and helped to draft the manuscript. All authors read and approved the final manuscript.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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