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Exploring the relationship between fairness and ‘brain types’ in children with high-functioning autism spectrum disorder

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ABSTRACT

Background: Existing research typically focuses on only one domain of cognition with regard to fairness—theory of mind or executive function. However, children with High-functioning autism spectrum disorder (HF-ASD) are cognitively impaired in both domains. Moreover, little is known about fairness characteristics in children with HF-ASD in relation to both domains of cognition.

Methods: Thirty children with HF-ASD as well as 39 children with typical development (TD) were evaluated in this study. We investigated the development of children's fairness characteristics as a responder in a mini ultimatum game (UG). The different ‘brain types,’ i.e., with or without HF-ASD, were evaluated using the Empathy Questionnaire-Systemizing Questionnaire (E/SC-Q). Furthermore, we explored the relationship between fairness and brain types using Pearson correlation analyses.

Results: Children in the HF-ASD group were more likely to accept unfair offers than were children in the TD group ($\chi^2 = 17.513$, $p = .025$). In the HF-ASD group, the acceptance rate of unfair offers was correlated with the discrepancy score ($r = 0.363$, $p = .048$), while there were no significant correlations in the TD group. In HF-ASD group, compared with Type S, acceptance rate of unfair offer was significant higher in Extreme Type S ‘brain type’ ($F = 28.584$, $p < .001$). While dividing TD participants by ‘brain type’, there was no significant difference in acceptance rate of unfair offer among five difference ‘brain types’ ($F = 1.131$, $p = .358$). Stepwise regression revealed that Extreme Type S positively predicted acceptance of unfair offers (F [1, 68] = 8.695, $p < .001$).

Discussion: Our findings show that children with HF-ASD were more likely to accept an unfair offer; in particular, the more unbalanced the development of empathy and systemizing was, the more significant the unfairness preference observed. Extreme Type S positively predicted the acceptance of unfair offers by children with HF-ASD.

Registration of clinical trials: World Health Organization class I registered international clinical trial platform, ChiCTR-ROC-17012877.

1. Introduction

“The way options are framed can induce bias in decision-making” (Shah et al., 2016). Fairness is one of the foundational features of human morality. Across cultures, there is a universal assumption that individuals should behave fairly and value fairly (Henrich et al., 2005; Rochat et al., 2009; Shaw and Olson, 2012). Fairness-related recognition and behavior development are important parts of one's pro-social development in childhood. Fairness plays an critical role in people's life, especially in decision-making, pointing to the fact that individuals are concerned not only with their maximum personal benefit but also with the fairness of profit distribution (P. Li et al., 2017). In daily life, people strive for fairness and are even willing to punish unfair behavior such that they pay a price for the sake of fairness. Experimental economic games are often used to measure people's sense of fairness, such as the dictator game (DG) and the ultimatum game (UG). Paradigms inspired by behavioral and economics are increasing used to investigate social cognitive processes underlying social interactions in psychiatric populations including Autism Spectrum Disorder (ASD) (Hasler, 2012; Sharp et al., 2012).

ASD is characterized by impairment in social communication and interaction and restricted and repetitive behavior or interests. The

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behavioral characteristics of HF-ASD abnormality can be understood and interpreted from the perspective of neuropsychology. In 2002, Baron-Cohen and his colleagues proposed the extreme male brain theory (EMB theory), which defined ASD as having two domains of cognitive deficit, namely empathizing and systemizing. 'Empathizing' is the drive to identify another person's emotions and thoughts and to respond to these with an appropriate emotion, which involves theory of mind (ToM). Empathizing allows you to predict a person's behavior and to care about how others feel (Baron-Cohen, 2002). Systemizing is the drive to analyze or construct systems. What defines a system is that it follows rules, and when we systemize we are trying to identify the rules that govern the system in order to predict how that system will behave (Baron-Cohen, 2006), which involves parts of executive function. Baron-Cohen and his colleagues suggested that people with ASD show significantly below average empathy and above average systemizing, both of which are traits that lead to the development of the extreme male brain (Baron-Cohen, 2009; Baron-Cohen et al., 2011). This two-factor theory can explain the cluster of both social and nonsocial features in autism spectrum disorder. Specifically, below average empathy is a simple way of explaining social and communication difficulties, while average or even above average systemizing is a way of explaining narrow interests, repetitive behavior, and resistance to change/need for sameness (Baron-Cohen, 1996; Hill, 2004b; Rumsey and Hamburger, 1988).

As a lifelong disease, ASD can cause stress in the community, is a serious burden on families, and can make it difficult to assimilate into society. Researchers reported that rates of violent behavior in ASD vary widely from 1.5% to 67%(Del Pozzo et al., 2018), and some studies supported an association between ASD and violence (Asperger, 1943; Baron-Cohen, 1988). Bjørkly (Bjørkly, 2009) investigated the motives of violence caused by Asperger individual's. Results indicated that some of the violent acts were motivated by communicative and social misinterpretations of other persons' intentions and being treated unfair. In China, research has shown that the mental health of parents of ASD children is poor and they frequently have some type of mental illness, such as anxiety, depression, self-blame, and are unsatisfied with life (Zhang et al., 2012; Zhou et al., 2010; Zhuang et al., 2017). The different social pattern and the deficit in social skills of children with ASD make it difficult for the latter to become involved in the real world. "The way to maintain work and social situations, particularly for those who are on the spectrum, is obviously to put on this facade of pretending to be normal. But it's very tiring and exhausting" (Pellicano et al., 2014). In schools, children with ASD are often isolated and even bullied by their classmates because they cannot integrate into the group. Some children are even attacked by their classmates in school without knowing how to protect themselves. Moreover, the restricted and repetitive behavior or interests of children with ASD are often regarded as odd or unnatural by students who are not educated about autism. Adults with ASD are less likely to have a well-paying job than non-autistic people; many have fewer social contacts and connections outside their immediate family, and many also struggle with their mental health and material well-being (Howlin et al., 2004, 2013; Howlin and Moss, 2012). Therefore, to better understand people with ASD, we have to better understand their social cognitive pattern. A sense of fairness affects the way people behave and their mental health, which in turn affects social harmony. It is relevant to our daily life. Fairness is a common research topic in the fields of psychology, sociology, and economics (Mou and Zhu, 2007). In sum, studying fairness characteristics helps us better understand the social cognitive characteristics of ASD, which can help deepen our understanding of ASD overall.

The results of existing game studies in the general population clearly indicate that the development of fairness in children and adolescents is related to ToM and executive function (EF) (Sally and Hill, 2006; Shochet et al., 2016; Su and Ma, 2014). Recently, research in psychology has suggested that people with ASD present abnormal fairness-related behavior compared with non-ASD counterparts and has also related this phenomenon to theory of mind (ToM) and EF. The ability to ToM, that is, to attribute mental states such as beliefs, desires, feelings, and intentions to others, is critical; it affects individuals' social decision-making (Frith and Singer, 2008) and is a necessary condition for demonstrating fairness in an economic game (Gummerum et al., 2008). Individuals with ASD have a fundamental difficulty metalizing, and social life for them is a series of strong headwinds, uncertain tacks, and treacherous eddies (Sally and Hill, 2006). Indeed, they are considered to lack theory of mind (Baron-Cohen et al., 1985; Baron-Cohen et al., 1993). Specifically, people with ASD fail to understand not only that others have minds but also that other minds have different thoughts and that behavior is determined by mental states. EF is an umbrella term for functions such as planning, working memory, impulse control, inhibition and mental flexibility as well as for the initiation and monitoring of action (Hill, 2004b). Over the past thirty years several executive functions have been studied in the context of autism, and it has been found that people with ASD experience difficulties with regard to planning, flexibility and inhibition (Hill, 2004a; Pennington and Ozonoff, 1996; Russell, 1997). Researchers have revealed that the deficiency of executive function will diminish the ability of ASD to abandon useless information from the pool filled with useful and useless information, which lead to ASD can't switch cognitive decisions according to specific situations (Hofmann et al., 2012; Jahromi et al., 2013). Sally (Sally and Hill, 2006) reported that, in fairness paradigm ASD showed poor strategy in different situations. However, most studies have tested the links between each domain of cognition (ToM or EF) and fairness-related behavioral traits in separate studies.

In this study, we hypothesized specific associations between two domains of cognitive impairment (empathy and systemizing) and fairness or between different brain types and fairness. This study used a group comparison, contrasting individuals with ASD and individuals with typical development. We aimed to explore the fairness characteristics of children with high-functioning autism spectrum disorder and their correlations with different 'brain type', and seeking for specific predictors of aberrant fairness characteristics in HF-ASD population.

2. Materials and methods

2.1. Participants

Thirty individuals with ASD (5 females) and thirty-nine typically developing healthy controls (5 females) participated in this study. Individuals with ASD were recruited from outpatient clinics at the Children's Mental Health Research Center of Nanjing Medical University Affiliated Brain Hospital, China, between May 2016 and July 2017; control participants were recruited from the community. Exclusion criteria were (central) neurological abnormalities; a history of epilepsy or seizures; head trauma; a history of serious somatic disease; neurological or mental diseases; the use of neurological or psychiatric medicines; or an IQ of < 80. Intelligence was estimated using the Wechsler Intelligence Scale for Children—third edition (WISC-III). All participants in the ASD group received research diagnoses of ASD according to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) criteria, based on the Autism Diagnostic Interview-Revised (ADI-R) parental interview, the Autism Diagnostic Observation Schedule (ADOS) and IQ.

For individuals with an ASD diagnosis, a family member completed the Autism Behavior Checklist (ABC) and the Childhood Autism Rating Scale (CARS). All participants completed an informed consent form, and study procedures were approved by the Medical Ethics Committee of the Nanjing Medical University affiliated Nanjing Brain Hospital (KY043).

2.2. Experiment task: mini ultimatum game

Ultimatum game was designed by Werner Güth, Rolf Schmittberger and Bernd Schwarze (Güth et al., 1982) in 1982 as an assessment tool for fairness. In 2000, Page et al. (Page et al., 2000) investigated stability of model structure by spatial dynamics, the results revealed very small mutation errors (ε), confirmed the stability of UG. Thereafter the game was widely used through the world for fairness assessment (Cameron, 2010; Slonim and Roth, 1998; Su and Ma, 2014). In 2003 Oosterbeek et al. (Oosterbeek and Kuilen, 2003) reported the findings of a meta-analysis of 37 papers with 75 results from Ultimatum Game experiments. Results explored that, the differences in outcomes are not related to differences across countries or cultures but just reflect differences between different locations. Currently, researchers applied this paradigm to different age groups, like preschool children (Takagishi et al., 2010), school children (Yu and Zhu, 2010), adolescent (Sally and Hill, 2006) and adults (Girardi et al., 2018; Gong et al., 2017). So far, there were 5 research articles used this paradigm to investigated the fairness characteristic in participants with ASD (Hartley and Fisher, 2018; Ikuse et al., 2017; Klapwijk et al., 2017; Sally and Hill, 2006; Su and Ma, 2014). In this research, we rerolled participants whose IQ were higher than 80, to make sure that they can follow the instructions while doing the game and to ensure the reliability of the experimental results.

In the Ultimatum Game, participants should play as proposer and responder, respectively. As 'proposer', player is endowed a sum of money and makes an offer to another player (the 'responder') on how to split this money between the two of them. The responder can either accept the offer, in which case the money is split as proposed, or reject the offer, in which case neither player receives anything and the money is returned to the experimenter. In this study, the mini-UG (Zhou et al., 2014) was used to measure fairness and was presented using *E*-prime 1.0 software on a personal computer. In mini-UG, the participant played the role of responder and was presented with nine offers, for a total of 18 decision-making rounds (see Table 1). An individual test was used in the experiment, and the specific experimental procedures were as follows:

In the first step, the participant entered the laboratory to familiarize him- or herself with the experiment environment.

In the second step, the method of operation of the mini-UG was explained in detail to the participant. Instructions were first displayed on the screen, and then the participant began to practice. The distribution plans in the practice segment differed from those in the actual experiment.

In the third step, the experiment started after ensuring that the participant fully understood the experimental requirements. Instructions were once again displayed on the screen. The participant was instructed to press the spacebar to start if they understood the instructions. The preparation time for each round was 2 s. Next, the computer showed the distribution plan proposed by a partner for 6 s. Then, the participant was asked to respond by pressing the "Accept" or "Reject" button; the decision had to be made in fewer than 6 s. Finally, the result was displayed. The experiment flowchart is shown in Fig. 1.

In the fourth step, the game finished, and the participant left the test environment and was given a small gift as a reward.

Table 1
Nine different offers in the fairness measurement.

Ultra-fair	Fair	Unfair
2:8	5:5	8:2
4:16	10:10	16:4
6:24	15:15	24:6

2.3. Brain type measure

In 2009, Baron-Cohen and his colleagues proposed the empathizing-systemizing theory (*E*-S theory) (Baron-Cohen, 2009). This theory suggests that each domain of cognition is normally distributed across the population and manifests differently in each individual. In the general population, women are more empathetic, and men are more systemizing. By comparing an individual's empathy and systemizing characteristics, Baron-Cohen found that it is possible to classify people into five different brain types:

- Type E (E > S): individuals whose empathy is stronger than their systemizing;
- Type S (S > E): individuals whose systemizing is stronger than their empathy;
- Type B (S = E): individuals whose empathy is as good (or as bad) as their systemizing (B stands for balanced);
- Extreme Type E (E ≥ S): individuals whose empathy is above average, but who are challenged in regard to systemizing;
- Extreme Type S (S ≥ E): individuals whose systemizing is above average, but who are challenged in regard to empathy (such as people with ASD).

Studies of the general population have shown that most people belong to Type B, although a greater proportion of men are of Type S and a greater proportion of women are of Type E. People with ASD mostly belong to Extreme Type S.

The Child Empathy Questionnaire-Systemizing Questionnaire (E/SQ-C)(Wakabayashi et al., 2006) was used to assess the empathy and systemizing characteristics of *E*-S theory. This questionnaire contains 55 items, 27 of which are from the Empathy Quotient (EQ-C) and 28 of which are from the Systemizing Quotient (SQ-C). Some items are reverse-scored. The scoring rules for the positively scored entries are "strongly agree" = 2 points, "agree" = 1 point, and "disagree"/"strongly disagree" = 0 points; those for the reverse-scored entries are "strongly disagree" = 2 points, "disagree" = 1 point, and "agree"/"strongly agree" = 0 points. The EQ-C and SQ-C scores are summed into a total score, and a higher total score denotes stronger traits in the corresponding characteristics.

The *E*-S discrepancy score (D score) (Huang, 2015) refers to the difference between the empathy score and the systemizing score according to E-S theory, divided into five different brain types. The mean total EQ-C (EQCm) and mean total SQ-C (SQCm) of the TD group were first calculated. Then, the original total EQ-C (EQCr) and SQ-C (SQCr) of each individual was subtracted from the mean EQ-C and mean SQ-C of the TD group, respectively; the results were divided by the maximum total score of all of the samples for the corresponding questionnaire (40 for EQ-C and 24 for SQ-C). The difference between the resulting normalized systemizing score (S) and empathy score (E) was then divided by 2 to obtain the D score. The specific formulas were as follows:

EQCr = original total EQ-C EQCm = mean total EQ-C of the TD group.
SQCr = original total SQ-C SQCm = mean total SQ-C of the TD group.
$E = (EQCr - EQCm)/40$ $S = (SQCr - SQCm)/24$.
$D = (S - E)/2$.

In 2015, researchers in Taiwan published the norm of cognition classification boundaries (Huang, 2015) based on D scores according to E-S theory (Auyeung et al., 2009; Baron-Cohen et al., 2005). The researchers classified $D < -0.205$ as Extreme Type E, $-0.205 < D < -0383$ as Type E, $0.038 < D < 0.037$ as Type B, $0.037 < D < 0.21$ as Type S, and $D \geq 0.21$ as Extreme Type S.

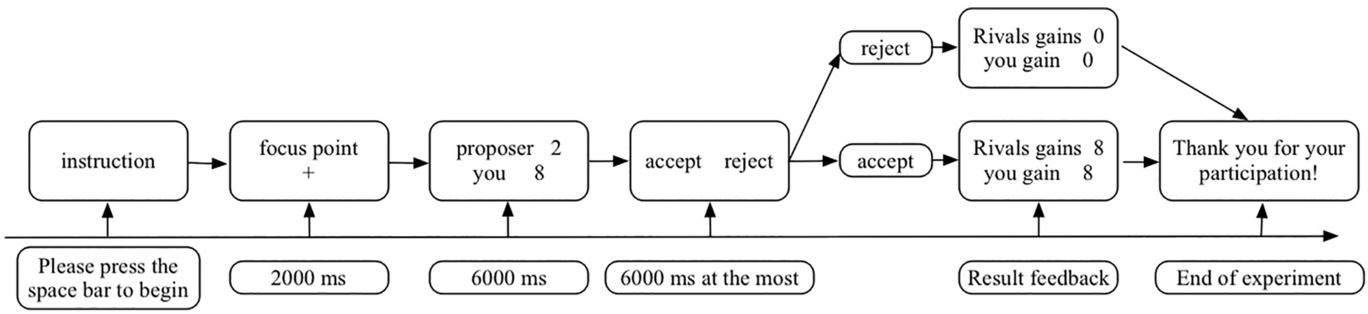

Fig. 1. Experiment flowchart.

2.4. Statistical analysis

A general linear model (GLM) with a 3 (fairness type) × 2 (group) factorial design matrix was constructed to analyze the behavior of each participant during the experiment. Data preparation and descriptive analyses were undertaken in SPSS 23.0. The analysis was divided into four steps. In step 1, the chi-square test was conducted to compare the demographic differences between the two groups. In step 2, Pearson's correlation was calculated to analyze the relationship between significant factors and fairness. In step 3, one-way ANOVA was used to conducted the unfairness acceptance rates in different 'brain type' in two groups, respectively. In step 4, a stepwise regression analysis was conducted to analyze the relationship between fairness and 'brain type' in HF-ASD groups. The significance level was set at $p < .05$.

3. Results

The HF-ASD group included a total of 25 males (25/30, 83.3%) and 5 females (5/30, 16.7%). The average age of this group was 9.07 ± 2.664 years old, and the participants' average IQ was 100.8 ± 20.860. The TD group included a total of 34 males (34/39, 87.2%) and 5 females (5/34,12.8%). The average age of this group was 9.51 ± 2.594 years old, and the participants' average IQ was 117.64 ± 11.177. An additional analysis showed that no significant between-group differences were present with regard to age ($\chi^2 = 9.240$, $p = .451$), gender ($\chi^2 = 0.202$, $p = .653$), or IQ ($\chi^2 = 45.941$, $p = .240$) (Table 2).

3.1. Fairness performance

The measurement of fairness did not reveal a significant difference in the acceptance rates of fair offers ($\chi^2 = 5.217$, $p = .633$) or ultra-fair offers ($\chi^2 = 10.829$, $p = .212$) between the HF-ASD and TD groups. However, the acceptance rate of unfair offers ($\chi^2 = 17.513$, $p = .025$) differed significantly between the two groups; specifically, the acceptance rate of the HF-ASD group was higher than that of the TD group (Fig. 2). No significant difference was found in response times between the two groups ($\chi^2 = 69.000$, $p = .410$) (Fig. 2).

3.2. Brain type

Regarding the E/SQ-C assessment, the HF-ASD group showed significantly lower empathy scores ($\chi^2 = 51.502$, $p = .028$) and significantly higher systemizing scores than the TD group ($\chi^2 = 64.144$, $p = .039$).

In terms of brain type distribution, the HF-ASD group was mostly composed of Extreme Type S (86.7%, 26/30) participants, while the remaining participants were Type S (13.3%, 4/30). The TD group was composed of 10.2% (4/39) Extreme Type S, 33.3% (13/39) Type S, 20.5% (8/39) type B, 28.2% (11/39) Type E, and 7.8% (3/39) Extreme Type E. A significant difference was found in the cognition distribution between the two groups ($\chi^2 = 42.446$, $p < .001$; see Table 2).

Table 2
Demographic and clinical characteristics of ASD and control participants.

	ASD group	TD group	t/χ^2
Gender			0.202
Male	25	34	
Female	5	5	
Age	9.07 ± 2.664	9.51 ± 2.594	9.240
IQ	100.8 ± 20.860	117.64 ± 11.177	45.941
ADI-R			
Social interaction	15.000 ± 4.127	–	–
Language	11.000 ± 3.414	–	–
Stereotyped behavior	4.900 ± 1.749	–	–
Onset	2.570 ± 0.898	–	–
ADOS			
Communication	5.100 ± 1.447	–	–
Social interaction	8.570 ± 1.073	–	–
Imagination/creativity	1.170 ± 0.834	–	–
Stereotyped behavior and imitation	1.970 ± 1.691	–	–
CARS	32.2 ± 2.14	–	–
EQ-C	18.60 ± 6.826	34.44 ± 8.416	51.502**
SQ-C	31.33 ± 12.441	12.03 ± 7.499	64.144**
Brain type			42.446***
Extreme Type E	0	3	
Type E	0	11	
Type B	0	8	
Type S	4	13	
Extreme Type S	26	4	

IQ = Intelligence Quotient; ADI = Autism Diagnostic Interview; ADOS = Autism Diagnostic Observation Schedule; ASD = autism spectrum disorder; CARS = Childhood Autism Rating Scale; EQ = Empathy Quotient; SQ = Systemizing Quotient.

** $p < .05$ for ASD versus Control.

*** $p < .001$ for ASD versus Control.

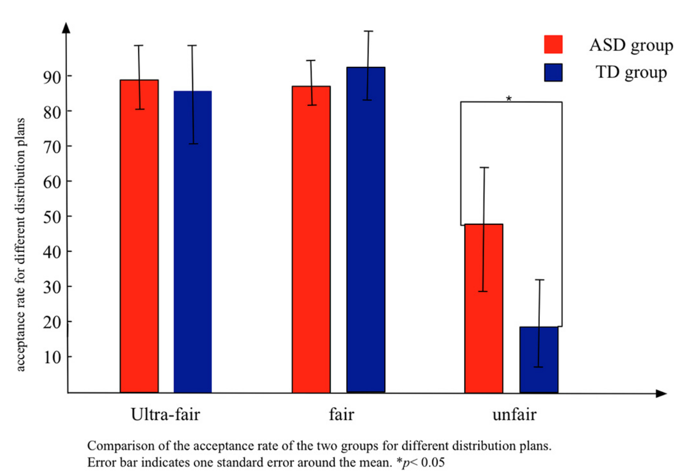

Fig. 2. Acceptance rates of the two groups across different distribution plans.

Table 3
ANOVA of brain type and fairness.

	ASD Group			TD Group		
	Ultra-fair	Fair	Unfair	Ultra-fair	Fair	Unfair
Brain types	2.897	0.085	28.584***	2.661	0.953	1.131
Extreme Type E				38.89 ± 30.932	100.00 ± 0.000	11.11 ± 5.557
Type E				92.42 ± 4.695	89.39 ± 6.061	31.82 ± 11.998
Type B				83.33 ± 12.599	89.56 ± 8.296	10.42 ± 6.999
Type S	75.00 ± 15.958	45.83 ± 20.834	48.07 ± 38.679	85.91 ± 7.265	97.44 ± 2.564	20.51 ± 8.680
Extreme Type S	91.67 ± 3.101	94.23 ± 2.055	51.67 ± 41.667	100.00 ± 0.000	75.00 ± 25.000	0.00 ± 0.000

*** $p < .001$.

3.3. Brain type and fairness

One-way ANOVA revealed that, in the HF-ASD group compared with S type, the acceptance rate in *E*-S type was significant higher ($F = 28.584$, $p < .001$). In TD group, there was no significant differences between 5 different 'brain type' ($F = 1.131$, $p = .358$).

In both group, there were no significant differences between 'brain type' and fairness acceptance rate, ultra-fair acceptance rate (see Table 3).

3.4. Relationship between unfairness acceptance rate and related factors

Pearson's correlation analysis revealed that, in the HF-ASD group, the acceptance rate of unfair offers was significantly and positively correlated with the discrepancy score ($r = 0.363$, $p = .048$). However, in the TD group, no factors were correlated with the acceptance rate of unfair offers, whether it be age, IQ, EQ, SQ, discrepancy score (see Table 4).

3.5. Stepwise regression analysis

In a further analysis, the variables associated with unfair offer acceptance rates (Extreme Type S, discrepancy score, IQ, age and Type S) were gradually included into the regression model in the order of the correlation coefficient magnitudes. The results suggest that Extreme Type S positively predicted the acceptance rate of unfair offers (F [1, 68] = 8.695, $p = .001$; see Table 5).

4. Discussion

This is the first study focusing on the relationship between two domains of cognition (ToM and EF) and fairness in people with HF-ASD. The study aimed to explore the specific associations between two domains of cognitive impairment (empathy and systemizing) and fairness, or between different brain types and fairness. Children in the HF-ASD group were more likely to accept unfair offers than children in the TD group. In the HF-ASD group, the acceptance rate of unfair offers was correlated with the discrepancy score and Extreme Type S, while there were no significant results in the TD group. Extreme Type S positively predicted acceptance of unfair offers. There were no effects between core symptoms and fairness in HF-ASD.

Table 4
Pearson correlations of unfairness acceptance rates and related factors.

	ASD group		TD group	
	r	*p*	*r*	*p*
Age	−0.067	0.726	0.182	0.268
IQ	−0.313	0.093	0.282	0.082
EQ	−0.142	0.454	−0.025	0.882
SQ	−0.121	0.523	−0.222	0.175
Discrepancy score	0.363*	0.048	−0.125	0.450
ADI-R			–	–
Social interaction	0.189	0.318		
Language	0.197	0.296		
Stereotyped behavior	0.152	0.421		
ADOS			–	–
Communication	0.199	0.292		
Social interaction	0.030	0.876		
CARS	−0.144	0.447	–	–

* $p < .05$.

Table 5
Stepwise regressions in ASD group.

	B	*SE*	*β*	*t*	*P*
Included variable					
Constants	63.313	24.370		2.598	0.016
Extreme Type S	47.913	12.590	0.704	3.806	0.001***
Discrepancy score	−2.221	17.800	−0.025	−0.125	0.902
IQ	−0.107	0.175	−0.095	−0.609	0.548
Age	−1.292	1.272	−0.146	−1.015	0.320
Excluded variable					
Type S					

*** $p < .001$.

Group comparison showed that no statistically significant difference was found between the two groups on gender, age, and IQ. With regard to the two dimensions of cognition (empathy and systemizing) based on the E/SQ-C, the HF-ASD group showed significantly lower empathy scores but significantly higher systemizing scores than the TD group. The brain types were further categorized based on the D score and the individual's empathy and systemizing scores. Significant differences in brain type distribution were found between the two groups. In the HF-ASD group, Extreme Type S was the predominant brain type (86.7%), while Type S accounted for 13.3% of the children in the group. In the TD group, 82% of the children belonged to Type E (33.3%), Type B (20.5%), and Type S (28.2%), whereas only 18% were Extreme Type S (10.2%) or Extreme Type E (7.8%). These results are in line with Baron-Cohen's *E*-S theory, and the cognitive distribution of the HF-ASD group was also consistent with EMB theory.

Behavior analysis shows that compared with gender-, IQ- and age-matched TD peers, the HF-ASD group showed a higher acceptance rate of unfair offers but a similar acceptance rate of ultra-fair and fair offers, which is consistent with previous findings (Klapwijk et al., 2017; Sally and Hill, 2006; Su and Ma, 2014; Zhou et al., 2014). Research on fairness-related behavior in the general population suggests that when participating in UG games as responders, children often reject low-price (unfair) offers as a punishment to the proposer (Blount, 1995; Falk et al., 2003). Murnighan and Saxon (1998) and Dong et al. (2016) elucidated the acceptance rates of children as responders at different ages with regard to different offers. The results indicated that starting at 4, children are able to identify others' intentions in games and will make appropriate decisions based on the intention of the proposer. As a responder, the confederate always rejected offers of less than an equal split (i.e., four or fewer points). The results of this study suggest that the development of a sense of fairness among children with HF-ASD was far behind that of TD peers.

Although not the primary aim of this study, we performed brain type-symptom analyses to explore whether the E/SQ was correlated with symptom severity as assessed by raw scores of the total CARS scores, ADI-R subscales scores (social interaction, and stereotyped behavior) and ADOS subscale scores (communication, social interaction, communication and social interaction, imagination/creativity, and stereotyped behavior and imitation). Participants with HF-ASD displayed a positive SQ- stereotyped behavior relationship. Across measures, a negative tendency ($p < .05$) was revealed toward EQ and ADI-R-Social interaction, ADOS (communication, social interaction, communication and social interaction, and imagination/creativity) (see Supplementary Table 1).

Then we used one-way ANOVA to exploring the relationship between different brain type and core symptoms of ASD. Results indicated that, compared with Type S, Extreme Type S subgroup had a higher but not significant scores in CARS, ADI-R subscales scores (social interaction, language and stereotyped behavior) and ADOS subscale scores (communication, social interaction, imagination/creativity, and stereotyped behavior/imitation) (see Supplementary Table 2).

According to Baron Cohen, ASD cognitive phenotype reflects one Extreme Type end of a continuum of brain types—one that is heavily biased toward "systemizing" rather than "empathizing" (Baron-Cohen, 2002). While systemizing are driven "to analyze the variables in a system, to derive the underlying rules that govern the behavior of a system", empathizers are driven "to identify another person's emotions and thoughts," thus enabling one to predict another person's behavior (Baron-Cohen, 2002; Baron-Cohen and Wheelwright, 2004). For HF-ASD, low empathy was associated with impairment of social communication, high systemizing was linked to restrict and stereotyped behavior. Pearson correlation reveals that SQ was positively associated with restrict and stereotyped behavior symptoms, that was consistent with previse studies. Through the Pearson correlation and one-way ANOVA, even most of the results are not significant, we still find a tendency between brain type and core symptoms of ASD, that was consistent with EMB theory.

The analysis of the correlation between fairness and general factors did not reveal a significant result between fairness and IQ, or age in either group. Previous studies have confirmed that fairness is age-related. Li et al. (2014) confirmed that children from 3 to 6 years old become more altruistic as they age. Sally and Hill (2006) studied four groups of participants including TD children aged 6, 8, and 10 years old as well as children with ASD aged 6 to 15 years old and did not find a correlation among IQ, and fairness. However (Sally and Hill, 2006), indicated that refusing unfairness varied with age. Six-year-olds (TD or ASD) were more likely to accept low (40% or less) offers, and this result was likely related to their inability to recognize the unfair intentions of others. However, in a study of 20- to 50-year-old adults, (Ikuse et al., 2017) found that fairness was not correlated with age or IQ. Slovic (1966) studied the decision-making behaviors of 6- to 16-year-olds. The results showed that the level of intellectual development was correlated with the decision-making behavior of children and adolescents, such that intellectually mature children and adolescents made better decisions. However, a study also found that empathy and IQ were relatively independent (Brune, 2003) from each other. Therefore, the relationship among fairness, age, and IQ must be further clarified in large-sample and age-stratified studies in the future.

No significant correlations between fairness and the ADI-R, ADOS and CARS subscales were observed in the HF-ASD group. Similarly, (Ikuse et al., 2017) did not find a significant correlation between the core symptoms of HF-ASD and fairness. Although some studies have been conducted on the fairness behavior of children with HF-ASD, they did not explore the relationship between the severity of the core symptoms of HF-ASD and fairness behavior (Li and Zhu, 2014; Sally and Hill, 2006; Su and Ma, 2014).

Frith and Singer (2008) indicated that most social interactions are influenced by our abstract beliefs, which focus more on who we interact with and less on the actual behavior or state of the person in the interaction. Therefore, when we socialize with someone, we try to predict their behavior based on a mode we assume is the same as ours. This is so-called 'cognitive empathy' (as in ToM) (Premack and Woodruff, 1978). However, previous findings (Frith and Singer, 2008; Lee, 2008) showed that, with a deficit in ToM (empathy), children with ASD showed abnormal fairness-related behavior. When participants engage in economic games, within the framework of game theory, they actually participate in a type of social interaction. Previous findings have confirmed that ToM (empathy) can be used to predict the fairness-related behavior of children with or without ASD (Sally and Hill, 2006; Shu and Ma, 2014). When children deal with different situations, better empathizing promotes more appropriate strategies in the game (Wang and Su, 2011, 2013). Studies in TD populations have shown that respondents often refuse offers that are < 30% of the total price in the UG (Camerer and Thale, 1995), whereas people with lower empathy levels are willing to accept offers at one-fifth of the total price. The unfairness acceptance rate of children with lower empathy was higher than that of their TD counterparts. Moreover, studies on schizophrenia, major depressive disorder (MDD) and Tourette's syndrome (TS) (Eddy et al., 2011) have also suggested that impairment in empathy development explains abnormalities in social decision-making. In this study, we did not find a relationship between EQ and fairness.

In a 2005 study, Y et al. (2005) indicated that ASD involves defects in executive function, including a lack of ability to develop insight for concept development or cognitive transfer. In daily life, people with ASD usually have difficulty planning and exhibit poor organizational abilities, impulsiveness, persistence, difficulty in adapting to changing situations, difficulty with self-adjustment, and a failure to filter out irrelevant interference. These difficulties are strongly associated with EF dysfunction. Some researchers (Hofmann et al., 2012; Jahromi et al., 2013) have indicated that children with ASD cannot make appropriate decisions or switch strategies based on the actual situation in the presence of a large amount of useful or useless information. This problem with switching strategies based on reality leads to one-way communication and restricted and repetitive behaviors (as highly systemized) on the part of people with ASD while taking part in a group. However, there is no significant correlation between SQ and fairness in this study. We considered that the SQ-C questionnaire within the E/SQ-C scale does not entirely measure the EF of children. Therefore, future research is needed to clarify the relationship between fairness and EF in youth with ASD using a more comprehensive EF evaluation.

The D score and fairness correlation analysis revealed that the acceptance rate of unfair offers was significantly and positively correlated with D score in the HF-ASD group but not in the TD group. The D score is defined as one-half of the difference between normalized S and normalized E. If the D score is > 0, then systemizing is greater than empathy; otherwise, empathy is greater than systemizing. According to the D score calculation, when patients with HF-ASD show more systemizing than empathy characteristics, they are more inclined to accept unfair offers. Conversely, when participants show more empathy than systemizing, they are more inclined to use rejection strategies. When made an unfair offer, children with typical development will realize it and reject it. On account of their developmental delay, however, children with ASD fail to recognize an unfair offer and usually choose to accept it. The current study showed that the D score was positively correlated with the acceptance rate of unfair offers, which suggests that children and adolescents with higher levels of empathy tend to reject unfair offers in a game, whereas those with higher levels of systemizing tend to accept unfair offers in a game. This supposition is also consistent with the significant and negative correlation between empathy and the acceptance rate of unfair offers found in this study.

In this study, we found that fairness was not related with either EQ or SQ. However, the balance of EQ and SQ was related with fairness. Divided participants with 'brain type' in ASD and TD group, respectively. In ASD group, compared with Type S, Extremely Type S have a significant higher unfair acceptance rate. In particular, follow-up stepwise regression analysis also suggested that this Extreme Type S positively predicted the acceptance of unfair offers in the UG game by children with HF-ASD. According to EMB theory, patients with HF-ASD and brain types closer to an extreme male brain are more likely to accept unfair game offers. That is, lower levels of empathizing and higher levels of systemizing are associated with more stereotyped acceptance of unfair situations among children with HF-ASD.

5. Conclusion

In summary, to our knowledge, this is the first study to explore the relationship between fairness and brain types in children with high-functioning autism spectrum disorder. The results suggested that children with HF-ASD were more likely to accept unfair offers; in particular, the more unbalanced the development of empathy and systemizing, the more significant the unfairness preference observed. The Extreme Type S positively predicted the acceptance of unfair offers in children with HF-ASD. Our findings thus inform the understanding that empathy/systemizing is not the independent cognitive dimension related to fairness but that empathy and systemizing both play a role in making unfairness-related decisions, the likelihood of which is especially associated with the balance of empathy and systemizing.

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Appendix A. Supplementary data

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References

Asperger, H., 1943. Die “Autistischen Psychopathen” im Kindesalter. Eur. Arch. Psychiatry Clin. Neurosci. 117 (1), 76–136.
Auyeung, B., Baroncohen, S., Ashwin, E., Knickmeyer, R., Taylor, K., Hackett, G., 2009. Fetal testosterone and autistic traits. Br. J. Psychol. 100 (1), 1–22.
Baron-Cohen, S., 1988. An assessment of violence in a young man with Asperger's syndrome. J. Child Psychol. Psychiatry 29 (3), 351–360.
Baron-Cohen, S., 1996. Mindblindness: An Essay on Autism and Theory of Mind. Vol. 19 MIT Press, Cambridge, MA.
Baron-Cohen, S., 2002. The extreme male brain theory of autism. Trends Cogn. Sci. 6 (6), 248–254.
Baron-Cohen, S., 2006. The hyper-systemizing, assortative mating theory of autism. Prog. Neuro-Psychopharmacol. Biol. Psychiatry 30 (5), 865–872. https://doi.org/10.1016/j.pnpbp.2006.01.010.
Baron-Cohen, S., 2009. Autism: the empathizing-systemizing (E-S) theory. Ann. N. Y. Acad. Sci. 1156, 68–80. https://doi.org/10.1111/j.1749-6632.2009.04467.x.
Baron-Cohen, S., Wheelwright, S., 2004. The empathy quotient: an investigation of adults with Asperger syndrome or high functioning autism, and normal sex differences. J. Autism Dev. Disord. 34 (2), 163–175.
Baron-Cohen, S., Wheelwright, S., Lawson, J., Griffin, R., Ashwin, C., Billington, J., Chakrabarti, B., 2005. Empathizing and Systemizing in Autism Spectrum Conditions.
Baron-Cohen, S., Leslie, A.M., Frith, U., 1985. Does the autistic child have a “theory of mind”? Cognition 21 (1), 37–46.
Baron-Cohen, S., Tager-Flusberg, H., Cohen, D., 1993. Understanding other minds. In: Perspectives From Autism. Oxford University Press, Oxford.
Baron-Cohen, S., Lombardo, M.V., Auyeung, B., Ashwin, E., Chakrabarti, B., Knickmeyer, R., 2011. Why are autism spectrum conditions more prevalent in males? PLoS Biol. 9 (6), e1001081. https://doi.org/10.1371/journal.pbio.1001081.
Bjørkly, S., 2009. Risk and dynamics of violence in Asperger's syndrome: a systematic review of the literature☆. Aggress. Violent Behav. 14 (5), 306–312.
Blount, S., 1995. When social outcomes aren't fair - the effect of causal attributions on preferences. Organ. Behav. Hum. Decis. Process. 63 (2), 131–144.
Brune, M., 2003. Theory of mind and the role of IQ in chronic disorganized schizophrenia. Schiz. Res. 60 (1), 57–64.
Camerer, C., Thale, R.H., 1995. Ultimatums, dictators and manners. J. Econ. Perspect. 9 (2), 209–219.
Cameron, L.A., 2010. Raising the stakes in the ultimatum game: experimental evidence from Indonesia. Econ. Inq. 37 (1), 47–59.
Del Pozzo, J., Roché, M.W., Silverstein, S.M., 2018. Violent behavior in autism spectrum disorders: Who's at risk? Aggress. Violent Behav. 39 (2018), 53–60. https://doi.org/10.1016/j.avb.2018.01.007.
Dong, S., Zheng, H., Wang, Y., Yu, Q., 2016. 4 to 6 years old children's fair intention development research. Stud. Psychol. Behav. 14 (3), 325–330.
Eddy, C.M., Mitchell, I.J., Beck, S.R., Cavanna, A.E., Rickards, H., 2011. Social reasoning in Tourette syndrome. Cognit. Neuropsychol. 16 (4), 326–347.
Falk, A., Fehr, E., Fischbacher, U., 2003. On the natrue of fair behaviour. Econ. Inq. 41 (1), 20–26.
Frith, C.D., Singer, T., 2008. The role of social cognition in decision making. Philos. Trans. R. Soc. Lond. Ser. B Biol. Sci. 363 (1511), 3875–3886. https://doi.org/10.1098/rstb.2008.0156.
Girardi, A., Sala, S.D., Macpherson, S.E., 2018. Theory of mind and the ultimatum game in healthy adult aging. Exp. Aging Res. 44 (3), 246–256.
Gong, X., Xia, L.X., Sun, Y., Guo, L., Carpenter, V.C., Fang, Y., Chen, Y., 2017. Proposal allocation ratio as a moderator of interpersonal responsibility effects on hostile decision-making in the ultimatum game. Front. Psychol. 8 (1959), 1–10. https://doi.org/10.3389/fpsyg.2017.01959.
Gummerum, M., Keller, M., Takezawa, M., Mata, J., 2008. To give or not to give: Children's and Adolescents' sharing and moral negotiations in economic decision situations. Child Dev. 79 (3), 562–576.
Güth, W., Schmittberger, R., Schwarze, B., 1982. An experimental analysis of ultimatum bargaining. J. Econ. Behav. Organ. 3 (4), 367–388.
Hartley, C., Fisher, S., 2018. Do children with autism spectrum disorder share fairly and reciprocally. J. Autism Dev. Disord. 1 (6), 1–13.
Hasler, G., 2012. Can the neuroeconomics revolution revolutionize psychiatry? Neurosci. Biobehav. Rev. 36 (1), 64–78. https://doi.org/10.1016/j.neubiorev.2011.04.011.
Henrich, J., Boyd, R., Bowles, S., Camerer, C., Fehr, E., Gintis, H., ... Tracer, D., 2005. “Economic man” in cross-cultural perspective: behavioral experiments in 15 small-scale societies. Behav. Brain Sci. 28 (06). https://doi.org/10.1017/s0140525x05000142.
Hill, E.L., 2004a. Evaluating the theory of executive dysfunction in autism. Dev. Rev. 24 (2004), 189–233.
Hill, E.L., 2004b. Executive dysfunction in autism. Trends Cogn. Sci. 8 (1), 26–32. https://doi.org/10.1016/j.tics.2003.11.003.
Hofmann, W., Schmeichel, B.J., Baddeley, A.D., 2012. Executive functions and self-regulation. Trends Cogn. Sci. 16 (3), 174–180. https://doi.org/10.1016/j.tics.2012.01.006.
Howlin, P., Moss, P., 2012. Adults with autism spectrum disorders. Can. J. Psychiatry 57 (5), 275–283.
Howlin, P., Goode, S., Hutton, J., Rutter, M., 2004. Adult outcome for children with autism. J. Child Psychol. Psychiatry 45 (2), 212–229.
Howlin, P., Moss, P., Savage, S., Rutter, M., 2013. Social outcomes in mid- to later adulthood among individuals diagnosed with autism and average nonverbal IQ as children. J. Am. Acad. Child Adolesc. Psychiatry 52 (6), 572–581. e571. https://doi.org/10.1016/j.jaac.2013.02.017.
Huang, H.-Y., 2015. Psychometric Properties of the Children's Empathy Quotient and Systemizing Quotient. National Taiwan University.
Ikuse, D., Tani, M., Itahashi, T., Yamada, H., Ohta, H., Morita, T., ... Iwanami, A., 2017. The effect of visual cues on performance in the ultimatum game in individuals with autism spectrum disorder. Psychiatry Res. 259 (1), 176–183. https://doi.org/10.1016/j.psychres.2017.10.013.
Jahromi, L.B., Bryce, C.I., Swanson, J., 2013. The importance of self-regulation for the school and peer engagement of children with high-functioning autism. Res. Autism Spectr. Disord. 7 (2), 235–246. https://doi.org/10.1016/j.rasd.2012.08.012.
Klapwijk, E.T., Aghajani, M., Lelieveld, G.J., van Lang, N.D.J., Popma, A., van der Wee, N.J.A., ... Vermeiren, R., 2017. Differential fairness decisions and brain responses after expressed emotions of others in boys with autism Spectrum disorders. J. Autism Dev. Disord. 47 (8), 2390–2400. https://doi.org/10.1007/s10803-017-3159-4.
Lee, D., 2008. Game theory and neural basis of social decision making. Nat. Neurosci. 11 (4), 1–14.
Li, Z., Niu, Y., Cao, X., 2014. Relationships among children's theory of mind, moral emotion and fair behavior. Chin. J. Clin. Psychol. 22 (2), 324–328. https://doi.org/10.16128/j.cnki.1005-3611.2014.02.033.
Li, P., Zhao, Y., He, L., 2017. A review of behavioral contract incentive theory under the perspective of fair preference. J. Southwest Univ. (Soc. Sci.) 37 (4), 137–140.
Li, J., Zhu, L., 2014. Cooperation in children with high-functioning autism. Acta Psychol. Sin. 9, 1301–1316.
Mou, Y., Zhu, L., 2007. The cognitive neural mechanism of fairness and cooperative behavior. Chin. J. Behav. Med. Sci. 16 (12), 1140–1141.
Murnighan, J.K., Saxon, M.S., 1998. Ultimatum bargaining by children and adults. J. Econ. Psychol. 19 (4), 415–445.
Oosterbeek, H., Kuilen, R.S.G.V.D., 2003. Cultural differences in ultimatum game experiments: evidence from a meta-analysis. Exp. Econ. 7 (2004), 171–188.
Page, K.M., Nowak, M.A., Sigmund, K., 2000. The spatial ultimatum game. Proc. Biol. Sci. 267 (1458), 2177–2182. https://doi.org/10.1098/rspb.2000.1266.
Pellicano, E., Dinsmore, A., Charman, T., 2014. What should autism research focus upon? Community views and priorities from the United Kingdom. Autism 18 (7), 756–770. https://doi.org/10.1177/1362361314529627.
Pennington, B.F., Ozonoff, S., 1996. Executive functions and developmental

psychopathology. J. Child Psychol. Psychiatry 37 (1), 51.
Premack, D., Woodruff, G., 1978. Does the chimpanzee have a theory of mind? Behav. Brain Sci. 1 (4), 515–526.
Rochat, P., Dias, M.D.G., Guo, L., Broesch, T., Passos-Ferreira, C., Winning, A., Berg, B., 2009. Fairness in distributive justice by 3- and 5-year-olds across seven cultures. J. Cross-Cult. Psychol. 40 (3), 416–442. https://doi.org/10.1177/0022022109332844.
Rumsey, J.M., Hamburger, S.D., 1988. Neuropsychological findings in high-functioning men with infantile autism, residual state. J. Clin. Exp. Neuropsychol. 10 (2), 201–221.
Russell, J., 1997. How executive disorders can bring about an inadequate 'theory of mind'. In: Russell, J. (Ed.), Autism as an Executive Disorder. Oxford University Press, New York, NY, pp. 256–304.
Sally, D., Hill, E., 2006. The development of interpersonal strategy: autism, theory-of-mind, cooperation and fairness. J. Econ. Psychol. 27 (1), 73–97. https://doi.org/10.1016/j.joep.2005.06.015.
Shah, P., Catmur, C., Bird, G., 2016. Emotional decision-making in autism spectrum disorder: the roles of interoception and alexithymia. Mol. Autism 7, 43. https://doi.org/10.1186/s13229-016-0104-x.
Sharp, C., Monterosso, J., Montague, P.R., 2012. Neuroeconomics: a bridge for translational research. Biol. Psychiatry 72 (2), 87–92. https://doi.org/10.1016/j.biopsych.2012.02.029.
Shaw, A., Olson, K.R., 2012. Children discard a resource to avoid inequity. J. Exp. Psychol. Gen. 141 (2), 382–395.
Shochet, I.M., Saggers, B.R., Carrington, S.B., Orr, J.A., Wurfl, A.M., Duncan, B.M., Smith, C.L., 2016. The cooperative research Centre for Living with autism (autism CRC) conceptual model to promote mental health for adolescents with ASD. Clin. Child. Fam. Psychol. Rev. 19 (2), 94–116. https://doi.org/10.1007/s10567-016-0203-4.
Slonim, R., Roth, A.E., 1998. Learning in high stakes ultimatum games: an experiment in the Slovak Republic. Econometrica 66 (3), 569–596.
Slovic, P., 1966. Risk-taking in children: age and sex differences. Child Dev. 37 (1), 169–176.
Su, Y., Ma, T., 2014. Fair decision making in children with autism spectrum disorder: theory-of -mind and self-other emotional recognition. J. Psychol. Sci. 37 (4), 985–992.
Takagishi, H., Kameshima, S., Schug, J., Koizumi, M., Yamagishi, T., 2010. Theory of mind enhances preference for fairness. J. Exp. Child Psychol. 105 (1), 130–137.
Wakabayashi, A., Baron-Cohen, S., Wheelwright, S., Goldenfeld, N., Delaney, J., Fine, D., ... Weil, L., 2006. Development of short forms of the empathy quotient (EQ-short) and the systemizing quotient (SQ-short). Personal. Individ. Differ. 41 (5), 929–940. https://doi.org/10.1016/j.paid.2006.03.017.
Wang, S., Su, Y., 2011. Fairness choices of children when facing different objects: the role of theory of mind. J. Southwest Univ. (Soc. Sci.) 37 (4), 26–32.
Wang, S., Su, Y., 2013. From understanding to utilizing: theory of mind and children's distributive justice. Acta Psychol. Sin. 45 (11), 1242–1250.
Y, L., X, Z., J, L., 2005. A study of executive function in children with high functioning autism and Asperger syndrome. Chin. Ment. Health J. 19 (3), 168–170.
Yu, J., Zhu, L., 2010. The development of children’s fair behaviour: evidence from experimental games. Adv. Psychol. Sci. 18 (7), 1182–1188.
Zhang, Y., Yang, L., Lei, J., Ma, R., 2012. Mental symptoms and coping styles of autistic cllildren's parents. Chin. Ment. Health J. 26 (10), 771–774.
Zhou, C., Zou, H., Heng, Z., Kuang, G., Fu, P., 2010. The correlativity between quality of life and coping style in the autistic children's parents. Chin. J. Behav. Med. Sci. 19 (12), 1113–1115. https://doi.org/10.3760/cma.j.i%n.1674-6554.2010.12.021.
Zhou, Y., Wang, Y., Rao, L.L., Yang, L.Q., Li, S., 2014. Money talks: neural substrate of modulation of fairness by monetary incentives. Front. Behav. Neurosci. 8 (150), 1–11. https://doi.org/10.3389/fnbeh.2014.00150.
Zhuang, M., Zhang, Y., Du, R., Fang, Q., Lu, X., Bao, M., 2017. Qualitative research on mental health status of autistic children's mothers. J. Nurs. Rehab. 16 (6), 611–614.