The Fair Decision-making of Children and Adolescents with High-functioning Autism Spectrum Disorder from the Perspective of Dual-process Theories

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Abstract

Background: Fairness, as a core component of moral society, has received much attention. At present, there are inconsistencies in the findings regarding the fair decision-making of high-functioning autism spectrum disorder (HF-ASD). Previous studies have shown that the fair decision-making of typically developing children is influenced by theory of mind(ToM) and executive function(EF).Dual-process theories propose that both intuitive processes and reasoning processes participate in fair decision-making. As those with HF-ASD have defects in both domains, this study aims to explore the differences in fair decision-making between children and adolescents with HF-ASD and those with typical development (TD).

Methods: We used a mini ultimatum game (mini-UG) to explore 31 children and adolescents with HF-ASD and 38 children and adolescents with TD. Ttests and chi-square tests are used to compare group differences, Pearson correlation analysis and stepwise regression analysis was used to analyse the influencing mechanism of the two groups' unfair acceptance rates.

Results: The results showed that children with HF-ASD were more likely to accept unfair offers, but when it came to adolescents, the difference was no longer significant. Regression analysis showed that the interaction between the Behavioral Regulation Index(BRI) and age could negatively predict the unfair acceptance rate of children and adolescents with HF-ASD. Working memory and ToM can negatively predict the unfair acceptance rate of those with TD.

Conclusion: This study concluded that the development of fair decision-making by children and adolescents with HF-ASD fell far behind that of those with TD. Intuition processes play a dominant role in the fair decision-making processes of children and adolescents with HF-ASD, and we believe that comorbidity, age, experience and emotional management are important factors influencing the fair decision-making of individuals with HF-ASD.

Background

Human beings are unique in that they can cooperate with other humans(1). A good society should enable people to experience stable and lasting cooperation, and only fairness can realize this. In our daily lives, we often pay attention to fairness. Therefore, fairness, as a core component of moral society, has received much attention from psychologists and economists. Autism spectrum disorder (ASD) is a severe neurodevelopmental disorder that begins in early childhood and is characterized by impairment in social communication and interaction and repetitive behaviours or interests (2). ASD comprises heterogeneous neurodevelopmental disorders with mild to severe clinical symptoms, and many ASDs are accompanied by intellectual disorders. Individuals with ASD whose IQ is equivalent to or higher than that of normally developing individuals are classified as havinghigh-functioning autism spectrum disorder (HF-ASD). Compared with individuals with other ASDs, this group is more likely to acquire the ability to work and live independently. However, it is difficult for those with HF-ASD to establish friendships with others and

cooperate with each other because of their deficits in social communication and interaction. Those with HF-ASD are at great risk of being bullied by typically developing peers in school or other places due to a lack of social skills, gradually leading to subsequent emotional and psychological problems and violent behaviours(3, 4).Some researchers have claimed that this risk may result from their misunderstanding of other people's intentions and their perception of unfair treatment(4-6), which results in HF-ASD children being less tolerant of unfair treatment. Kate Anne Woodcock et al. used anUG to study the fair decision-making of HF-ASD children between 11 and 17 years old; the results showed that there was no significant difference between those with HF-ASD and those with TD when in the role of recipient(7). Other researchers conducted research on HF-ASD populations aged 6-16 years old, and the results indicated that children with HF-ASD were more likely to accept unfair distribution; Sally claimed that this higher acceptance rate might be related to defects in theory of mind (ToM)(8, 9). At present, research on fair decision-making in individuals with HF-ASD is primarily focused on theory of mind, but there are also studies showing that individuals with HF-ASD have difficulty changing strategies in gambling games, possibly due to defects in their executive functions(EFs)(8, 10-12). However, Susan Faja et al. found thatindividuals with HF-ASD did notsignificantly differ from those with TD in social decision-making and flexibility of goal orientation(13).Some researchers have claimed that fairdecision-making not only involves ToM but also is influenced by outcomesof decision-making, that is, the rational cognitive part of fair decision-making(14). Research on the neural mechanism of TD also shows that fairness-related decisions are regulated not only by ToM but also by a series of cognitive processes(15). Some researchers use dual-process theories to explain fair decision-making ofthose with TD.Dual-process theories separatesType 1 intuitive processes fromType 2 reasoning processes(16-18). The intuitive process is independent and does not require working memory. It is a fast, automatic process that enables the processing of large amounts of information simultaneously. Some studies classify emotions as intuitive processes, while reasoning processes depend on working memory and are capable of representing reality.Self-management inhibit the results ofintuitive processingto realize reasoning processes. Dual-process theories hold that the interaction of cognition and emotion can alter the fair decision-making of those with TD(15, 19).In addition, some researchers used cognitive tasks (such as syllogistic reasoning or cognitive reflection tasks, CRT) to study the theory of dual processing in ASD populations and concluded that ASD populations rely more heavily on inference processing than on intuitive processing(20-22).

ToM isthe ability to understand and predict others' feelings and behaviours.Compared with those with TD, those with HF-ASD have defects in the ability to inferothers mind(23), which makes them unable to make appropriate social decisions that require measuring the interests of themselves and others(14). EF is a set of cognitive processes, including inhibition, shift, monitor, plan/organize, and working memory. Researchers also found that those with ASD have impaired EF(24). Some studies have found that EF is related to ToM in ASD populations, and some researchers have claimed that EF is a prerequisite ofToM(25-28). Therefore, we assume that EF and ToM may simultaneously affect the fair decision-making of those with HF-ASD and that the dual processing mechanism of fair decision-making in HF-ASD populations is different from that in TD populations. To our knowledge, there are only two studies on

these two aspects of fair decision-making in individuals with HF-ASD. One discusses the influence mechanism of fair decision-making in individuals with HF-ASD from the perspective of ‘brain types’(9).The study found that the unbalanced development of HF-ASD ‘brain types’, that is, the imbalance between systemizing and empathy, causesindividuals with HF-ASD to have greater tolerance for unfair distribution(9). From the behavioural perspective, Kate Anne Woodcock et al. Usedthe ultimate game and found that individuals with HF-ASD are more influenced by ToM when acting as the proposerin fair decision-making games but aremore influenced by EFwhen acting as the responder(7).Ultimately, there are different conclusions regarding the fair decision-making of individuals with HF-ASD, and little is known about the role of ToM and EF in the fair decision-making of individuals with HF-ASD.Therefore, this study aims to explore the differences in fair decision-making between children and adolescents with HF-ASD andthose with TD and further discusses the possible psychological mechanism behind these differences from the perspective of dual-process theories.

Methods

2.1 Participants

We recruited thirty-one HF-ASD participants (4 females) fromoutpatient clinics at the Children's Mental Health Research Center of Nanjing Medical University Affiliated Brain Hospital and 38 TD participants(5 females) from the community.

The inclusion criteria for the HF-ASD group were as follows: (1)met the diagnostic criteria for ASD according to the Diagnostic and Statistical Manual of Mental Disorders-fifth edition(DSM-5);(2) met the scoring standards of the Autism Diagnostic Interview-Revised (ADI-R) and Autism Diagnostic Observation Schedule (ADOS);(3)was 6-16 years old, with a Wechsler Intelligence Scale for Children—third edition (WISC-III)Full-Scale Intelligence Quotien(FIQ) greater than 80;(4) received parental permission to participate in the study;(5) beingright handed.

The exclusion criteria for the HF-ASD group were as follows: (1)having a history of head trauma; (2) having a neurological or mental disease;and (3)using neurological or psychiatric drugs.

The inclusion criteria for the TD group were as follows: (1)being TD, with an age, sex and IQ that matched those of the HF-ASD group;(2)received parental permission to participate in the study;and (3)being right handedness.

The exclusion criteria for the TD group were as follows: (1) having a history of head trauma; (2) having a neurological or mental disease; and (3) using neurological or psychiatric drugs.

The study was approved by the Medical Ethics Committee of the Nanjing Medical University Affiliated Brain Hospital (KY043), and all participants signed informed consent forms.

2.2 Materials and analysis

2.2.1 Assessment

(1) Behavior Rating Inventory of Executive Function (BRIEF)(29)

BRIEF is a questionnaire for parents of school-age children that enables professionals to assess EFs. It is designed for a broad range of children between 5 and 18 years of age. This scale contains 86 items, all of which are three-level scoring items.It is divided into two sub-indexes:the Behavioral Regulation Index (BRI) and Metacognition Index(MI).The BRI includes Inhibition, Shift and Emotional control.The MI includes five factors: Initiate, Working Memory, Plan/Organize, Organization of Materials and Monitoring.BRI and MI scores form the Global Executive Composite (GEC), which represents the overall level of EF deficit. The higherthe score is, the more seriousthe deficit.

(2) Griffith Empathy Measure—Parent Report(GEM-PR)(30)

The GEM-PR is a scale of empathy for children and adolescents that is completed by parents according to the actual situation of their children. There are 23 items, all of which are scored on a 9-point scale. The higher the total score is, the greater the empathy.The total table is divided into two dimensions: Cognitive Empathy (GEM-C) and Affective Empathy (GEM-A).

(3)Ultimatum Game

In recent years, researchers have often used games, including the ultimatum game(UG),dictator game(DG)and prisoner's dilemma(PD), to study fair decision-making.The UG designed by Güth Schmittberger and Schwarze is one of the most commonly used of these games(31).In UG experiments, participants are given a fixed amount of funds and are assigned to a proposer orresponder role. The proposerproposes an allocation of funds, and if the responder accepts, the funds will be dispersed according to the proposer's allocation.Ifnot, both parties receive an amount of 0.In this study, a simple version of the UG was used. In the test, the subjects were assigned to only theresponder role and provided with 9 different allocations. Each allocation was presented twice for a total of 18 rounds (see Table 1).Presented by E-prime 1.0, the test procedure is as follows.

Step 1: The participants are familiarized with the experimental environment

Step 2: The operation mode is explained to the participants, who are then shown the instructions on a computer screen. The participants then complete a practice test.The practice allocation scheme differs from the formal allocation scheme.

Step 3: The participants’ familiarity with the task is tested, and the experiment begins.The instructions areagain displayed on the screen, and the "spacebar"is pressed to start the experiment.The preparation time for each round is 2 seconds.For each round, the computer screen displays the proposer’s allocation for 6 seconds.Then, the participants are asked to respond by pressing the "accept" or "reject" button. The decision process does not exceed 6 seconds.Finally, the results are displayed.

2.2.2 Statistical analysis

SPSS 23.0 software was used for statistical analysis.First, independent sample T tests and chi-squaretests were used to compare the differences insex, age and IQ between the two groups. Then, chi-squaretests were used to compare the acceptance rates of three different allocations between the two groups and the unfair acceptance rates of the two groups by age group.Pearson correlation analysis was used to explore the influencing factors of the two groups' unfair acceptance rates, and then, stepwise regression analysis was used to analyse the influencing mechanism of the two groups' unfair acceptance rates.

Results

The HF-ASD group included a total of 27 males and 4 females. The average age of this group was 9.065±2.6949 years, and the participants' average IQ was 106.10±17.762.The TD group included a total of 33 males and 5 females. The average age of this group was 9,718±2.7620 years, and the participants' average IQ was 117.68±11.324.There were no significant differences in sex, age, IQ, GEM-Aor GEM between the two groups, while there were significant differences in BRIEF and GEM-C scores ($P < 0.05$) (See Table 2 for results).

3.1 Acceptance rates of two groups for different allocations

The UG results show that there was no significant difference between the two groups in the acceptance rate of ultra-fair offers (c^2=3.477, P =0,062) and fair offers (c^2=0.019, P =0.889).However, the acceptance rate of unfair allocations (c^2=36.398, P =0,000) was significantly different, and the HF-ASD group accepted unfair allocations at a higher rate (see Table 3 for results).

Subsequently, we divided the HF-ASD group and TD group into childhood (≤11 yearsold) and adolescence (> 11 yearsold) groups to compare their unfair acceptance rates (Fig. 2). The unfair acceptance rate of the childhood HF-ASD group (M=52.67, SD=38.99) was higher than that of the adolescence HF-ASD group (M=22.22, SD=20.18), but the difference was not significant (Fig. 2a).Comparing the unfair acceptance rate of the HF-ASD group withthat of the TD group, it was found that the unfair acceptance rate of the childhoodASD group was significantly higher than that of the childhoodTD group (c^2=19.297, P=0.002), but the difference was not significant for the adolescence groups (c^2=3.134, P=0.970) (Fig. 2b).

3.2 Relationship between the unfair acceptance rates of the two groups and related factors

Pearson correlations found that the unfair acceptance rate of the HF-ASD group was significantly negatively correlated with BRIscores (r=-0.357, P = 0.049), while that of the TD group was significantly negatively correlated with GEM-Cscores (r=-0.360, P= 0.026)(see Table 4 for results).

3.3 Stepwise regression analysis of two groups

3.3.1 Stepwise regression analysis ofthe ASD group

Pearson correlations found that the BRIof the ASD group was moderately correlated with total EF (GEC) (r=0.684, P=0.000) and age (r=0.372, P=0.018).Therefore, BRI, BRI*GEC and BRI* age were all included in the stepwise regression analysis. The results showed that the interaction between BRI score and age in the ASD group is a negative predictor of unfair acceptance rate, with an explanation of 14.5% (see Table 5 for results).

3.3.2 Stepwise regression analysis ofthe TD group

Pearson correlations revealed that the GEM-C score in the TD group had a medium-low correlation with IQ(r=0.351, P=0.031), working memory (r=-0.399, P=0.037), monitoring (r=-0.391, P=0.015), MIscore (r=-0.351, P=0.031) and GEMscore (r=0.544, P=0.000); thus, GEM-C, GEM-C*IQ, GEM-C* working memory, GEM-C* monitor, GEM-C*MI and GEM-C*GEM wereincluded in the stepwise regression model. The interaction between GEM-C and working memory was found to be a negative predictor of the unfair acceptance rates of the TD group, with a total explanation of 15.8% (see Table 6 for results).

Discussion

This study explored the fair decision-making of individuals with HF-ASD and IQ and age-matched TD individuals in the UG.The HF-ASD group showed acceptedunfair offers at a higher rate than the TD group, while there was no significant difference between the acceptance rates for ultra-fair offers and fair offers, which was consistent with previous findings(8, 32).Researchers have found that typically developing children and adolescents usually reject unfair offers and, as a third party, tend to punish unfair individuals(33, 34).Moreover, some researchers believe that human beings show a preference for fairness when they are 12 months old and can already make decisions according to each other's distribution intentions and distribution results when they are 4 years old(35, 36).Therefore, the results of this study suggest that the development of a sense of fairness among individuals with HF-ASD lags behind that of typically developing individualsof the same age.

Previous studies have claimed that fair decision-making in children varies with age(8, 37).In this study, the HF-ASD group and TD group were stratified by age.The results show that individuals with HF-ASD are more inclined to accept unfair distributions in childhood but not in adolescence, possibly due to the small sample size in this study.The unfair acceptance rates of two HF-ASD age groups were compared with those of the TD age groups. The unfair acceptance rates of the childhood HF-ASD group were significantly higher than those in the childhood TD group, but no significant difference was between the two adolescence groups, possibly because children showing TD through the age of 6 have developed a sense of fairness, while children with ASD slowly develop a sense of fairness when they are teenagers.

In the general population, ToM, as the basis for cooperation, is often considered to participate in fairness-related behaviours(38, 39).Accordingly, we found that the unfair acceptance rates of children and adolescents with TDwere related to the GEM, that is, ToM.Individuals with ASD are often considered to

lack the ability to understand the intentions of others. In previous studies, fairness-related behaviours were shown to be related to ToM development defects(40), but no consistent conclusion was found in our study.At the same time, we found that the unfair acceptance rates of children and adolescents with HF-ASD are related to BRI EF scores, which is consistent with previous results(7, 8, 10, 11). Further regression analysis shows that both psychological theory and working memory have an impact on the unfair acceptance rate of individuals with TD.According to the dual-process theories of fair decision-making, the intuitive process is a fast, non-logical process independent of working memory.Matthias Sutter et al. have shown that when there is a time limit in decision-making, participants will accept a more unfair distribution(41); that is, their reactions arise from intuitive processes.Other researchers classify emotion-related factors, such as negative emotions generated by unfair distributions, as a result of respondents' intuitive processes(42).The reasoning process is a slow process that depends on working memory and operates on information from the specific situation.In line with Pennycook et al.(18, 43), we believe that the fair decision-making of individuals with TD is affected by bothintuitive processes and reasoning processes (see Fig. 2).However, compared withindividuals with TD, those with HF-ASD have defects in ToM and EF.Some researchers claim that individuals with HF-ASD may avoid social stimulation due to these deficits, so they cannot follow the daily norms of social cooperation and cannot learn the concepts of fair and unfair from the social environment(32). Ourstudy found that the interaction between the BRIEFscores of individuals with HF-ASD and age can negatively predict unfair acceptance rates.Therefore, we can conclude that the dual processing of individuals with HF-ASD differs from that ofindividuals with TD (see Fig. 2).Self-management plays a role in inhibiting intuitive processes and activating the reasoning process in dual processing.Eliran Halali et al. have shown that self-regulatory depletion, which results from inhibiting related tasks before UG experiments, leads to an increase in the rejection rate of unfair distribution(44).BRI EF scores represent effective self-management through effective inhibition to change cognition andthen regulate emotion and behaviour.In individuals with HF-ASD, the BRI revealsdeficits. Therefore, we believe that intuitive processing plays a leading role in the fair decision-making of individuals with HF-ASD.In addition, individuals with HF-ASD may be more "selfish" due to defects inToM, whichmakes them seem as if they are living in their own world.They consider only their own interests and losses and will not experience negative emotions in response to unfair offers.Acceptance may be intuitive to these individuals, hencetheir higher rates of accepting unfair offers. In this research,we didn’t excluded HF-ASD who is also suffered from Attention Deficit Hyperactivity Disorder(ADHD). In our opinion, when ASD comorbid with ADHD are forced to undergo a series of negative social experiences regarding unfairness in social activities. In later life, negative emotions accompany similar situations. Meanwhile, behaviour management weakens with age, which leads to a failure of emotional control. In addition, the intuitive process occupies the dominant position in individuals with HF-ASD+ADHD, and experience is just a part of the intuitive process. Therefore, selfish nature conflicts with experience, andindividuals with HF-ASD+ADHD are unableto adjust and adapt, thus leading to negative emotions. Finally, individuals with HF-ASD+ADHD are unable to adjust the negative emotions caused by experiences and conflicts due to poor behaviour management skills, so they are immersed in their own emotional world and experience a stronger emotional response to unfairness.Therefore, with age, their reaction to unfair events strengthen. In our sample, the dual

processing mode of the HF-ASD population was dominated by intuitive processing, and this finding conflicts with previous research results on the dual processing mode of HF-ASD populations. First, the task of our study differs from those in previous studies. We use a simple gambling gamethat focuses on gain and loss, while previous studies have used more complex reasoning tasks (for example, if five machines need 5 minutes to make five widgets, how long will it take to make 100 machines to make 100 widgets?). Second, previous studies have focused on teens and adults over the age of 16, not children and adolescents under 16. Finally, individuals with ADHD were not strictly excluded from the HF-ASD group, so further studies are needed. Meanwhile, due to the small sample size in this study, a larger sample size may be needed for further research and verification.

Fair decision-making is a complicated social behaviour.Similarly, the results of this study show that EF and ToM cannot fully predict fair decision-making in children and adolescents with TD or HF-ASD.Dual-process theories of a sense of fair decision-makingsupport this finding(16). in addition to the factors involved in the two processes studies herereality representation capabilities may impact rates of accepting unfair distributions.Therefore, future research may need to include these factors for analysis.

Conclusion

This paper finds that the development of fair decision-making in individuals with HF-ASD lags behind that in individuals with TD, and individuals with HF-ASD are more likely to accept unfair offers. The study also found that the interaction between BRIscore and age affected the fair decision-making of children and adolescents in the HF-ASD group.Therefore, this paper proposes that the influencing mechanisms behind the fair decision-making of individuals with HF-ASD and TD may differ. The fair decision-making of individuals with HF-ASD may be dominated by intuitive processing, and we believe that comorbidity, age, experience and emotional management are important factors influencing the fair decision-making of individuals with HF-ASD.Variations in stimulation or the environment can affect the social cognition of individuals with HF-ASD.

Abbreviations

1.high-functioning autism spectrum disorder: HF-ASD

2.theory of mind:ToM

3.executive function: EF

4.typical development:TD

5. mini ultimatum game: mini-UG

6.Behavioral Regulation Index: BRI

7.cognitive reflection tasks: CRT

8.the Diagnostic and Statistical Manual of Mental Disorders-fifth edition: DSM-5

9. the Autism Diagnostic Interview-Revised : ADI-R
10. Autism Diagnostic Observation Schedule:ADOS

11.Wechsler Intelligence Scale for Children—third edition:WISC-III

12.Full-Scale Intelligence Quotient:FIQ

13.Behavior Rating Inventory of Executive Function: BRIEF

14.Metacognition Index: MI

15.Global Executive Composite: GEC

16.Griffith Empathy Measure—Parent Report: GEM-PR

17.Cognitive Empathy: GEM-C

18.Affective Empathy: GEM-A

19.dictator game: DG

20.prisoner's dilemma: PD

21.Attention Deficit Hyperactivity Disorder: ADHD

Declarations

Ethics approval and consent to participate: Our study involving human participants and this study was approved by the Medical Ethics Committee of the Nanjing Medical University Affiliated Brain Hospital (KY043), and all participants signed informed consent forms. Details that might disclose the identity of the subjects under study have been omitted.

Availability of data and materials The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests The authors declare that they have no competing interests.

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Tables

Table 1

Ultimatum game with 9 different offers

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

Table 2

Demographic and clinical characteristics of ASD and TD participants.

	HF-ASD（$M\pm SD$）	TD ($M\pm SD$)	t/c^2
Sex			0.000
Male	27	33	
Female	4	5	
Age	9.065±2.6949	9,718±2.7620	-0.994
IQ	106.10±17.762	117.68±11.324	49.060
BRIEF			
Inhibit	60.161±10.4182	47.846±9.9645	5.034***
Shift	58.871±8.7967	49.949±8.5838	4.273***
Emotional control	56.419±10.7758	45.821±9.0956	4.462***
BRI	59.645±9.2971	47.051±9.8807	5.436***
Initiate	60.065±8.7937	48.128±7.4593	6.143***
Working memory	62.968±9.1012	48.590±7.3439	7.317***
Plan/Organize	64.419±10.0558	52.256±7.5209	5.790***
rganization of materials	54.806±8.2761	49.000±8.0099	2.969**
Monitor	65.000±9.0995	52.256±8.7139	5.960***
MI	63.290±8.5448	49.974±7.3143	7.022***
GEC	63.000±7.6463	49.077±7.9053	7.426***
GEM-PR			
GEM-C	-0.0537±0.8854	1.1578±1.2996	-4.418***
GEM-A	1.1577±0.8993	0.9093±1.0061	1.069
GEM	0.6942±0.6471	0.9860±0.7376	-1.726

**P 0.05

***P 0.001

Table 3

Acceptance rates of the HF-ASD and TDgroups for different allocations

	HF-ASD ($M \pm SD$)	TD ($M \pm SD$)	c^2
ultra-fair	86.559±23.341	83.761±30.225	3.477
fair	85.483±25.727	88.461±26.256	0.019
unfair	46.774±37.864	22.222±31.140	36.398***

**P 0.05

***P 0.001

Table 4

Relationship between the unfair acceptance rates of the two groups and related factors

	HF-ASD		TD	
	r	*P*	*r*	*P*
Age	-0.314	0.086	0.226	0.172
IQ	-0.276	0.133	0.219	0.187
BRIEF				
Inhibit	-0.223	0.229	0.103	0.540
Shift	-0.343	0.059	-0.033	0.844
Emotional control	-0.302	0.099	-0.078	0.640
BRI	-0.357	0.049**	0.012	0.941
Initiate	-0.150	0.422	-0.004	0.983
Working memory	-0.068	0.716	-0.205	0.217
Plan/Organize	0.075	0.688	-0.118	0.482
nization of materials	-0.114	0.542	0.000	0.999
Monitor	0.018	0.925	0.122	0.467
MI	-0.033	0.860	-0.049	0.769
GEC	-0.192	0.301	0.007	0.969
GEM-PR				
GEM-C	0.047	0.801	-0.360	0.026**
GEM-A	-0.073	0.695	0.021	0.899
GEM	-0.018	0.924	-0.168	0.314

**P 0.05

***P 0.001

Table 5

Stepwise regression analysis ofthe ASD group

		B	*SE*	*β*	*t*
Included variable					
	Constants	84.248	18.066		4.663***
	BRI*age	-0.68	0.031	-0.381	-2.218**
Excluded variable					
	BRI			-0.173	-0.699
	BRI*GEC			-0.130	-0.579

**P 0.05

***P 0.001

Table 6

Stepwise regression analysis ofthe TD group

		B	*SE*	*β*	*t*
Included variable					
	Constants	33.937	6.379		5.320***
	GEM-C*working memory	-2.11	0.081	-0.398	-2.600**
Excluded variable					
	GEM-C			0.716	0.948
	GEM-C*monitor			1.334	1.649
	GEM-C*MI			1.591	1.340
	GEM-C*IQ			0.402	0.712
	GEM-C*GEM			0.015	0.059

**P 0.05

***P 0.001

Figures

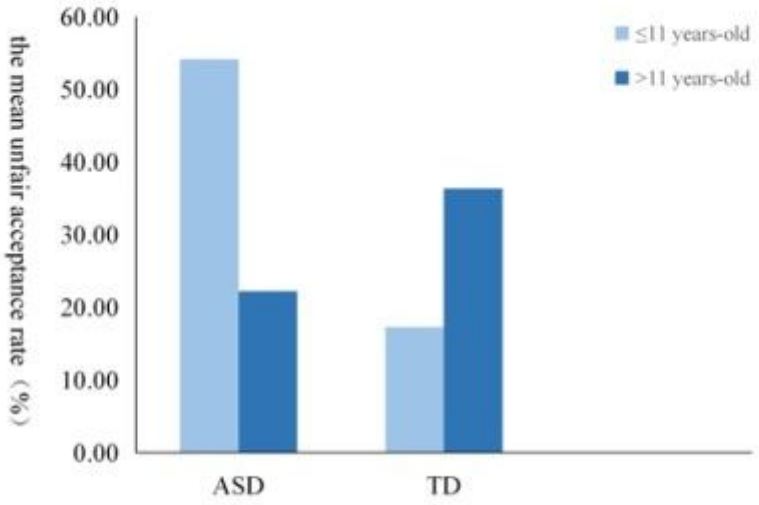

Fig 1a Comparison of unfair acceptance rates between childhood and adolescence

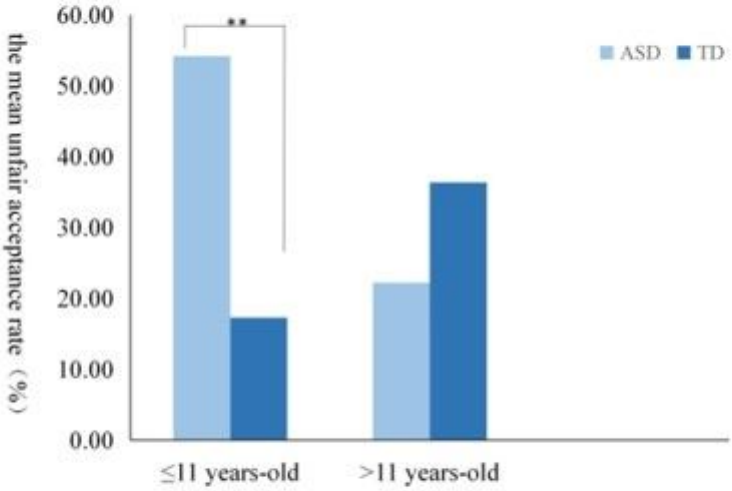

Fig 1b Comparison of unfair acceptance rates between two groups at different ages

Fig 1 Unfair acceptance rates at different ages in both groups. ** *P*< 0.05

11 / 12

Figure 1

Fig 1a Comparison of unfair acceptance rates between childhood and adolescence Comparison of unfair acceptance rates between two groups at different ages Fig 1 Unfair acceptance rates at different ages in both groups. ** P< 0.05

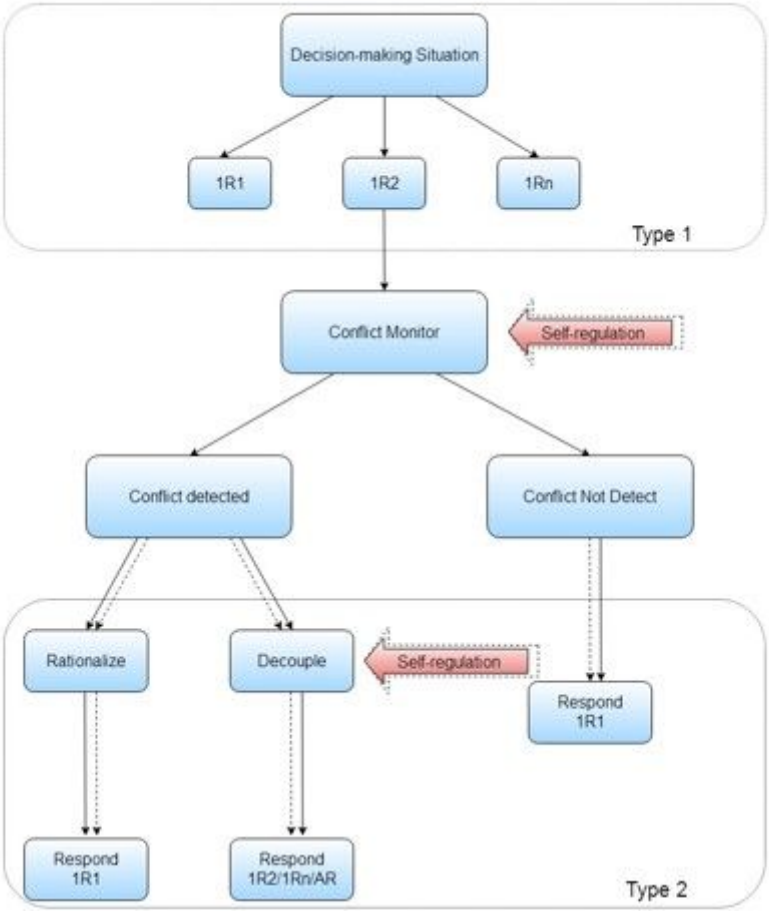

Fig.2-Dual-process theories of individuals with TD and individuals with HF-ASD. 1R1 is the most salient and fluentpossible response, 1Rn is the other possible intuitive reaction, and AR refers to alternative reaction. The dashed line represents weakenedprocesses in individuals with ASD.

Figure 2

Fig.2-Dual-process theories of individuals with TD and individuals with HF-ASD. 1R1 is the most salient and fluentpossible response, 1Rn is the other possible intuitive reaction, and AR refers to alternative reaction. The dashed line represents weakenedprocesses in individuals with ASD.