ORIGINAL RESEARCH

Parents' impaired emotion recognition abilities are related to children's autistic symptoms in autism spectrum disorder

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Objective: We aimed to explore whether parents of children with autism spectrum disorder (ASD) had impaired emotion recognition abilities and whether this deficit was related to their children's autistic symptoms.

Methods: The autistic symptoms of 31 ASD children were assessed using the Autism Diagnostic Interview-Revised (ADI-R). Fifty parents of ASD children and 34 parents of typically developing (TD) children completed an emotion recognition task (ERT).

Results: The numbers of correct ERT responses were lower for parents of ASD children than for parents of TD children with respect to recognizing sadness, disgust, fear, and all emotions (P=0.01, 0.04, 0.02, and 0.00, respectively). Controlled for parental age, gender, and the intelligence quotients of both the parents and children, a negative correlation was found between the total number of correct ERT responses for parents of ASD children and these children's "restricted, repetitive, and stereotyped patterns of behavior" scores on the ADI-R (r=−0.32; P=0.03).

Conclusion: Parents of ASD children showed impaired emotion recognition abilities compared with parents of TD children. This parental deficit in emotion recognition ability was related to the autistic symptoms of ASD children.

Keywords: autism spectrum disorder, parents, emotion recognition

Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by deficits in social communication and the presence of stereotyped repetitive interests and activities.[1] The Autism and Developmental Disabilities Monitoring Network in USA reported that in 2014, the prevalence of ASDs had increased to 1 in 68;[2,3] the corresponding prevalence in Mainland China in 2014 was 0.28%–6.22%.[4,5] ASD, a lifelong disorder, imposes heavy health and economic burdens on individuals, families, and societies.[6,7]

Functional deficits in social cognition have been found in ASD ranging from toddlers to adults,[7,8] and facial emotion recognition is one of the most important parts of social-cognitive function.[9] Loukusa et al[10] found that ASD children had impaired emotion recognition compared with typically developing (TD) children or children with specific language impairment. Sachse et al[11] found that high-functioning ASD children performed worse with respect to recognizing simple and complex facial emotions than did patients with paranoid schizophrenia or TD individuals. Certain meta-analysis studies have also reported that ASD children exhibit facial emotion recognition deficits across multiple expressions, especially when observing negative emotions,

and that these deficits are independent of intelligence.[12–14] Moreover, a functional magnetic resonance imaging (fMRI) study indicated that the emotion recognition deficits in ASD children could be predicted by hypoconnectivity of the superior temporal sulcus.[15] In early research on ASD, the superior temporal sulcus was implicated in eye gaze processing and voice perception. The amygdala has also been linked to emotion recognition and theory of mind deficits in autism, while the fusiform gyrus has been proposed as a mechanism underlying face processing deficits in autism.[16] Besides gray matter, white matter tracts of the socioemotional processing system were also found to be abnormally connected, such as the longitudinal fasciculus, splenium fibers, and the optic tract.[17] Both, functional and anatomical abnormalities have been observed in social cognition brain areas in ASD.

In addition, individuals with autism and their parents and siblings all have impaired emotion recognition abilities. The study by Bölte and Poustka[18] reported that there was a tendency for subjects from multiplex families with autistic loading to score lower on emotion recognition tasks (ERTs) than individuals from simplex families with autistic loading, and the extent of facial recognition deficits likely indexes an elevation in familial burden. Other studies exploring the association between facial emotion recognition deficits and functional polymorphism of the serotonin transporter (5HTTLPR) have reported that 5HTTLPR polymorphism may determine different error patterns.[19] Hence, we suggest that facial emotion recognition is a candidate endophenotype for autism. Endophenotypes are heritable markers associated with a given condition and can provide insight into its etiology.[20] The study of endophenotypes is particularly useful in understanding autism because they are diagnosed based on the clinical features but are of neurobiological origin and can aid in better identifying and characterizing the nature of the genetic contributions to this complex disorder.

However, there is no consensus regarding emotion recognition deficits in parents of ASD children. Palermo et al[21] found that parents of ASD children performed worse on an ERT than did parents of TD children. Kadak et al[22] reported that parents of ASD children had difficulty in recognizing neutral facial expressions. However, Bölte and Poustka[18] found that parents of ASD children did not differ from healthy controls with respect to their ability to judge facial affect. According to the studies by Kadak et al[22] and Adolphs et al,[23] the positive results of these two studies may have been caused by the failure to control demographic differences (eg, education years and intelligence quotients [IQs]) and the difficulty of the ERTs. Furthermore, the study in the early time by Palermo et al[21] only matched control parents by educational level and not on

the basis of a standardized test of intelligence. The experiment materials used in these three studies may also contribute to the different results reported. The study by Palermo et al[21] used schematic line drawings of male faces rather than real pictures, similar to that used by Kadak et al[22] and Adolphs et al.[23] In addition, the previous studies investigated only the relationships between symptoms of parents and their emotion recognition. Exploring the relationship between the emotion recognition abilities of parents of ASD children and these children's autistic symptoms may help us better understand the role of heredity and other variations in autism.

Methods
Participants
All the participants were consecutive from the beginning. Thirty-one ASD children (28 males/3 females) were recruited from the outpatient department of West China Hospital of Sichuan University (24 ASD children), a special education school (four ASD children), and a normal primary school (three ASD children) in Chengdu, China. Three experienced psychiatrists diagnosed and assessed these children using the *Diagnostic and Statistical Manual of Mental Disorders*, fifth edition (DSM-V) and the Autism Diagnostic Interview-Revised (ADI-R). All the psychiatrists completed training courses for the ADI-R. Interrater reliability was evaluated using the kappa coefficient (kappa=0.85).

Twenty-four TD children (21 males/3 females) were recruited from three normal primary schools via posted advertisements. Neither the ASD children nor the TD children had any comorbid medical or neurological conditions such as fragile X syndrome. All the ASD and TD children were assessed using the Kiddie Schedule for Affective Disorders and Schizophrenia for School-Age Children Present and Lifetime version (K-SADS-PL). Nine of the ASD children were diagnosed with attention deficit/hyperactivity disorder (ADHD). None of the TD children were diagnosed with any other psychiatric disorders. Fifty parents of ASD children (26 males/24 females) and 34 parents of TD children (14 males/20 females) were recruited. None of the parents had any psychiatric disorders. This study was approved by the ethical committee of West China Hospital and followed the guidelines set forth in the Declaration of Helsinki. All subjects signed informed consent forms and understood the precise purposes and processes of the research prior to participating in this study.

Cognitive assessment
The Chinese version of the Wechsler Intelligence Scale III was used to evaluate the intelligence of all parents and

children. Verbal intelligence quotient (VIQ), performance intelligence quotient (PIQ), and total IQ were recorded.

The parents of ASD and TD children were presented with the ERT component of the Cambridge Neuropsychological Test Automated Battery (CANTAB) Eclipse Test (Administration Guide Manual version 5.0.0, http://www.cambridgecognition.com/), which involved a set of computerized paradigms run on a Lenovo-compatible computer with a high-resolution color monitor and a touch-sensitive screen. The ERT, developed at the University of Bristol by Professor Marcus Munafõ and Dr Ian Penton-Voak, is a task of social cognition that measures the ability to identify emotions in facial expressions and was validated in a previous study by Yip and Lee.[24] It was also used in a study on emotion recognition in Chinese people with schizophrenia.[25] The parents were shown a series of faces that were computer-morphed images derived from facial features of actual individuals. Each face showed a specific emotion, and the faces were displayed onscreen, one at a time, in a random order. Each face was displayed for 200 ms and was then immediately obscured to prevent residual processing of the image. The participant was required to select which emotion the face displayed from six options (sadness, happiness, fear, anger, disgust, and surprise). There were two blocks, each containing 90 faces (15 faces per emotion). The number of correct responses for each emotion and the total number of correct responses for the recognition of all emotions were measured.

Data analyses

The SPSS version 23.0 for Windows (IBM Corporation, Armonk, NY, USA; www.ibm.com/software/analytics/spss/) was used for statistical analyses. Descriptive statistics were used for demographic and clinical variables. Gender, parent age at the birth of the relevant child, family history of mental disorder, and family income were analyzed using chi-squared tests; age and years of education as well as IQ, ERT, and ADI-R scores were analyzed using two-sample t-tests. Partial correlation analysis was conducted to relate ERT results that significantly differed between groups with ADI-R scores of ASD children, controlled for parental age, gender, and IQ. Bonferroni correction was performed to control the rate of type I errors when conducting multiple correlations. All the tests were two tailed, with a significance threshold of $P<0.05$.

Results
Demographic and clinical characteristics

There were no significant differences in age (t=1.10; P=0.29), gender (t=1.29; P=0.26), or family income (χ^2=5.57; P=0.14)

between ASD children and TD children. A family history of mental illness was more common in ASD children than in TD children (χ^2=4.63; P=0.03), and ASD children had lower VIQ, PIQ, and total IQ scores than TD children (t=−5.57, −6.90, and −6.39, respectively; P=0.00 for all). The parents of ASD and TD children did not significantly differ with respect to age, gender, age when the relevant child was born, years of education, VIQ, PIQ, or total IQ (t=1.75, 0.95, 2.96, 0.92, 0.33, 0.45, and 0.45, respectively; P=0.09, 0.33, 0.40, 0.36, 0.74, 0.66, and 0.66, respectively; Tables 1 and 2).

ERT scores for parents of ASD children and parents of TD children

The number of correct ERT responses was lower for parents of ASD children than for parents of TD children with respect to recognizing sadness, disgust, fear, and all emotions (t=−2.79, −2.10, −2.39, and −3.23, respectively; P=0.01, 0.04, 0.02, and 0.00, respectively). However, the number of correct ERT responses did not significantly differ between these two groups with respect to recognizing happiness, anger, or surprise (Table 2; t=−0.63, −1.43, and −0.71, respectively; P=0.54, 0.15, and 0.48, respectively).

Correlation between total number of correct ERT responses by parents of ASD children and these children's ADI-R scores

We conducted partial correlation analysis relating ERT results that significantly differed between groups with the ADI-R scores of ASD children, controlled for parental age, gender, and the IQs of both the parents and children. A negative correlation was found between the total number of correct ERT responses for all six emotions by parents of ASD children and these children's "repetitive behaviors and stereotyped pattern" scores on the ADI-R (r=−0.32; P=0.03) before Bonferroni correction (Figures 1 and 2). These parents' total number of correct ERT responses was not significantly related to the ASD children's scores on the "social and communication" subscales of the ADI-R (r=−0.12; P=0.13).

Discussion

We found that parents of ASD children performed worse than parents of TD children with respect to recognizing sadness, fear, and disgust during the ERT. This finding suggested that parents of ASD children exhibited impaired emotion recognition abilities for negative emotions and that this impairment is associated with autism. Our result is similar to the findings reported by Kadak et al,[22] Wallace et al,[26]

Table 1 Demographic and clinical characteristics of ASD and TD children

	ASD children (n=31)		TD children (n=24)		χ^2/t	P-value
	n	%	n	%		
Gender						
Male	28	90.32	21	87.50	1.29	0.26
Female	3	9.68	3	12.50		
Family income (¥CNY)						
<3,000	12	24.00	5	14.71	5.57	0.14
3–5,000	16	32.00	9	26.47		
5–8,000	11	22.00	13	38.23		
>8,000	11	22.00	7	20.59		
Family history	8	25.82	1	4.17	4.63	0.03*
	Mean	SD	Mean	SD	χ^2/t	P-value
Age (years)	8.57	2.29	7.43	2.19	1.10	0.29
IQ						
VIQ	69.70	19.95	97.50	15.78	−5.57	0.00**
PIQ	64.53	17.04	93.16	11.94	−6.90	0.00**
Total	66.56	18.49	95.50	13.69	−6.39	0.00**
ADI-R						
Communication	23.12	8.71	NA	NA		
Reciprocal social interaction	18.88	6.60	NA	NA		
Repetitive behaviors and stereotyped patterns	3.36	2.84	NA	NA		
Total score	48.24	16.05	NA	NA		

Notes: *P<0.05; **P<0.01.
Abbreviations: ADI-R, Autism Diagnostic Interview-Revised; ASD, autism spectrum disorder; CNY, Chinese Yuan; IQ, intelligence quotient; NA, not applicable; PIQ, performance intelligence quotient; TD, typically developing; VIQ, verbal intelligence quotient.

and Palermo et al[21] that the fathers of autistic children performed more poorly on tasks of emotion recognition than either these children's mothers or the control subjects. However, Bölte and Poustka[18] found that ASD parents did not perform differently from healthy controls on an emotion recognition test. As the studies by Kadak et al[22] and Adolphs et al[23] failed to control for demographic differences (ie, education years and IQs) and used different statistical methods, they obtained different outcomes.

We further found that the total number of correct ERT responses provided by parents of ASD children was negatively related to these children's "restricted, repetitive, and stereotyped patterns of behavior" scores on the ADI-R. This result suggested that this important social cognition deficit of the parents of ASD children was related to these children's autistic symptom severity, particularly with respect to repetitive and stereotyped symptoms. To our knowledge, this article provides the first report of an association between a social cognition deficit in the parents of ASD children and the severity of those children's autistic symptoms, although other

social behaviors or cognition phenotypes in parents have been found to be related to ASD children's autistic symptoms.[27,28] It has been reported that the social skills and communication ability of ASD children's mothers were related to the severity of ASD children's autistic symptoms.[27] The mitigation of autistic symptoms in ASD children has been associated with an increased empathy in their parents.[28]

Several studies on social cognition in mental disorders, such as schizophrenia, have indicated that impaired emorecognition ability of individuals is related to symptom severity.[29–32] Deficits in emotion recognition that extend beyond the recognition of facial expressions have been associated with reciprocal social interaction symptoms in autism.[33] In our study, we found an between social cognition deficit in ASD parents and ASD children's autistic symptom severity.

Our study found that the "repetitive and stereotyped symptoms" of children were correlated with parents' ability in emotion recognition, but the "social and communication" subscale was not correlated, which may seem surprising.

Table 2 Demographic characteristics and ERT scores of ASC's and TDC's parents

	Parents of ASC (n=50)		Parents of TDC (n=34)		χ^2/t	P-value
	n	%	n	%		
Gender						
Male	26	52.00	14	41.18	0.95	0.33
Female	24	48.00	20	58.82		
Age of giving birth (years)						
<25	11	22.00	7	20.58	2.96	0.40
25–30	11	22.00	13	38.24		
30–35	16	32.00	9	26.47		
>35	12	24.00	5	14.71		
	Mean	SD	Mean	SD	χ^2/t	P-value
Age (years)	36.12	5.46	34.12	4.67	1.75	0.09
Education years	12.62	3.80	11.97	2.67	0.92	0.36
IQ						
VIQ	104.84	13.74	98.71	12.73	0.33	0.74
PIQ	101.36	17.41	100.00	13.08	0.45	0.66
Total	103.84	14.07	99.44	12.73	0.45	0.66
Correct number of ERT						
Happy	22.72	4.07	23.26	3.45	−0.63	0.54
Anger	10.96	4.50	12.35	4.16	−1.43	0.15
Sad	15.82	6.18	18.13	4.35	−2.79	0.01*
Disgust	10.70	5.82	13.23	4.81	−2.10	0.04*
Fear	7.90	4.13	10.59	5.60	−2.39	0.02*
Surprise	19.26	4.43	19.94	4.21	−0.71	0.48
Total	88.10	13.21	98.18	16.08	−3.23	0.00**

Notes: *$P<0.05$; **$P<0.01$.
Abbreviations: ASC, autism spectrum disorder children; ERT, emotion recognition task; IQ, intelligence quotient; PIQ, performance intelligence quotient; TDC, typically developing children; VIQ, verbal intelligence quotient.
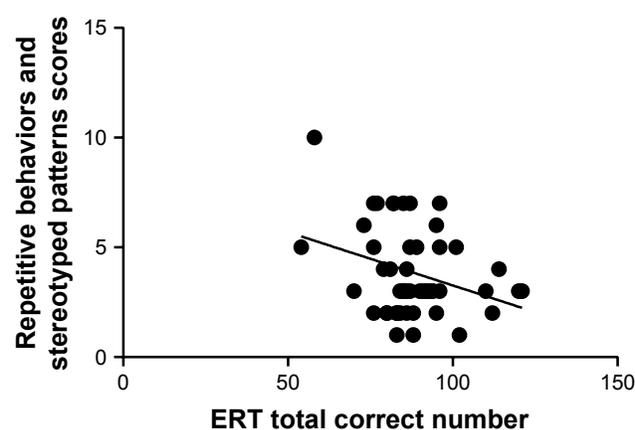

Figure 1 Negative correlation was found between the total number of correct ERT responses for recognizing all six types of emotions by parents of ASD children and these children's "repetitive behaviors and stereotyped pattern" scores on the ADI-R ($r=-0.32$; $P=0.03$), controlled for parental age, gender, and IQ of both the parents and children.
Abbreviations: ADI-R, Autism Diagnostic Interview-Revised; ASD, autism spectrum disorder; ERT, emotion recognition task; IQ, intelligence quotient.

Studies on sibling correlations have consistently shown that repetitive behaviors are correlated among siblings, while impairments in social reciprocity are not.[34] In addition, it is usually repetitive behaviors for which significant linkage results are reported in sub-type linkage analyses of ASD.[35] A phenotypic homogeneity analysis by Hus et al[36] reported that only restricted and repetitive behaviors associated with insistence on sameness were independent of age, IQ, and autism severity. Above all, we suggest that the repetitive and stereotyped symptoms were more highly and stably hereditary than social and communication symptoms.

These findings suggested that in the future, the social cognition deficits of ASD parents may be used to predict symptoms severity for their children, even when these children are at extremely early stages and are not exhibiting many symptoms, and to screen high-risk subjects. Our results
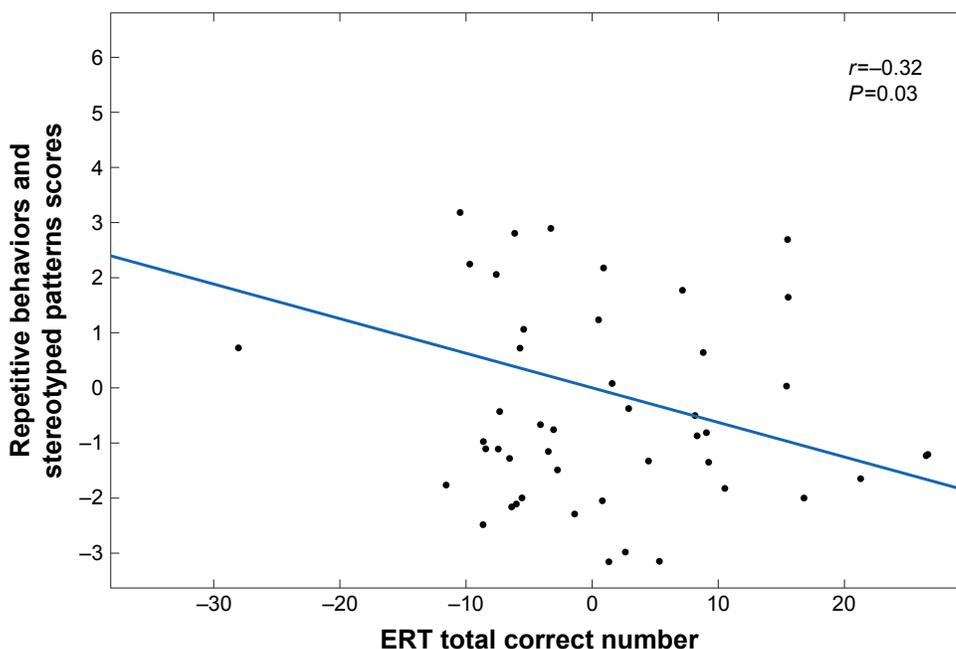
Figure 2 Partial correlation plot showed the negative correlation between the total number of correct ERT responses for recognizing all six types of emotions by parents of ASD children and these children's "repetitive behaviors and stereotyped pattern" scores on the ADI-R ($r=-0.32$; $P=0.03$), controlled for parental age, gender, and IQ of both the parents and children.
Abbreviations: ADI-R, Autism Diagnostic Interview-Revised; ASD, autism spectrum disorder; ERT, emotion recognition task; IQ, intelligence quotient.

may also help facilitate early diagnosis of ASD in toddlers, which is a challenging population for ASD diagnosis.

In terms of the underlying mechanism explaining our results, evidence from neuroimages has shown that certain brain regions (such as the amygdala) are responsible for both emotion cognition and repetitive, stereotyped symptoms in autism and their relatives.[26,37] Animal studies have revealed different neuronal subsets in the amygdala, namely, the GABAergic and glutamatergic subpopulations. The GABAergic subpopulation promotes aggression and two other social behaviors, whereas neighboring glutamatergic neurons promote repetitive self-grooming.[38] These results suggest that social behaviors and repetitive and social behaviors are controlled in an antagonistic manner by inhibitory and excitatory amygdala subpopulations, respectively.[39]

There is an explanation for the uncorrelated relationship between parents' emotion recognition and children's social impairment symptoms: emotion recognition may be an intermediate phenotype rather than a specific feature of autistic symptoms. As Cook et al[40] reported, emotion recognition is related to alexithymia rather than autistic traits. Based on the report by Bird and Cook[41] on ASD individuals with alexithymia representing a subgroup of autism, we can draw the same conclusion as Szatmari et al[42] that the alexithymia trait represented by emotion recognition impairment makes up the broader autism phenotype of parents of ASD children. What

is more, children's autistic symptoms can also be aggravated in family life. Other studies have explored how the emotional reaction of parents affects the behavior and emotional competence of children in normal populations.[43,44]

Unfortunately, in this study, we did not obtain sufficient information regarding the ERT performance of ASD children because only a few of these children completed the ERT assessment. To find more substantial evidence of association between emotion recognition and autistic symptoms in children and emotion, we need to obtain additional information about ASD children's ERT performance in the future.

Conclusion

Our study found impaired emotion recognition abilities in parents of ASD children, and this impairment was associated with these children's autistic symptoms. Our research suggested that the emotion recognition ability deficits of ASD parents may be an important cognition phenotype in ASD families and could be a promising biomarker for predicting symptom severity.

Ethics approval and consent to participate

Before taking part in the study, all participants were informed about the study and provided written informed consent,

which was approved by the Medical Research Ethics Committee of West China Hospital, Sichuan University.

Informed consent

Consent for the publication of clinical data and information was obtained.

Acknowledgments

Author contributions

All authors contributed to data analysis, drafting and revising the article, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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