Eur. J. Psychiat. 2017;31(2):59–65

THE EUROPEAN JOURNAL OF PSYCHIATRY

www.elsevier.es/ejpsy

ORIGINAL ARTICLE

IQ profiles and clinical symptoms of Chinese school-aged boys with autism spectrum disorder

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Received 19 December 2016; accepted 6 April 2017
Available online 9 May 2017

KEYWORDS
Autism spectrum disorder;
Intelligence quotient;
Wechsler Intelligence Scale for Children-IV Chinese version

Abstract
Background and objective: The cognitive abilities of individuals with autism spectrum disorder (ASD) vary widely, but studies have not yet examined Chinese school-aged boys with ASD in a systematic way.

This study aims to explore the IQ profile of Chinese school-aged boys with ASD; and the correlation of IQ and related symptoms.
Methods: Thirty-one boys with ASD and forty-eight typically developing (TD) boys were examined using the WISC-IV Chinese version. The relationship between IQ index scores and ASD symptoms was explored.
Results: For boys with ASD, in comparison to the TD Group, significantly lower scores were found for the Verbal Comprehension Index (VCI), Processing Speed Index (PSI) and Full Scale IQ (FSIQ). Examination of the Verbal IQ-Nonverbal IQ pattern across groups revealed differences between the ASD and the TD groups ($x^2 = 13.282$, $p = .001$). For the ASD sample, a negative correlation was observed between all the Index scores and the Level & Consistency of Intellectual Response score.
Conclusions: Our results indicated that Chinese school-aged boys with ASD show a different pattern of intellectual ability from their TD peers, with equivalent abilities in the PRI and WMI.

Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by pervasive deficits in social

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http://dx.doi.org/10.1016/j.ejpsy.2017.04.001

communication and social interaction, as well as restricted, repetitive patterns of behavior, interests, or activities. The intellectual and cognitive abilities of individuals with ASD vary widely, ranging from significantly impaired to gifted.[1]

Intelligence tests are a mainstay in ASD clinical practice and research assessment, aiding in the identification of intellectual disability that can accompany ASD, as well as guiding the development of individualized educational plans. IQ scores are also associated with social functioning and can predict cognitive outcomes later in life. For example, a 40-year follow-up research study showed that IQ was stable across the lifespan for children with IQs greater than or equal to 70.[2] Within a research context, IQ scores are commonly used as the basis for identifying and characterizing appropriate experimental and control groups, with the Wechsler IQ series being the most commonly used for these purposes.[3]

In regard to IQ profiles, when the Wechsler Intelligence Scale for Children-IV (WISC-IV) was first released, Williams et al. reported that all the IQ Index scores [i.e., Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI), Processing Speed Index score (PSI) and Full Scale IQ (FSIQ)] were significantly lower for children with autism than an age-matched, typically developing control group.[4] In addition, children with Asperger syndrome showed a lower PSI compared to a control group of age-matched, typically developing children, but other IQ Index scores (i.e., VCI, PRI, WMI, and FSIQ) were equal to the control group on the WISC-IV. Oliveras-Rentas at al. also found the weakness of PSI in high functioning autism.[5] Further, Mayes and Calhoun used the WISC-IV and found that the results are generally consistent with previous findings from studies using the Wechsler Intelligence Scale for Children-III (WISC-III).[6,7] In particular, children with high-functioning autism showed relatively lower scores on the WMI and PSI when compared to the VCI and PRI. They also reported that for the VCI subtests, the Comprehension score was the lowest, whereas Similarities was the highest score. In addition, the Matrix Reasoning subtest, which is part of the PRI, was the highest score compared to other PRI subtests. This latter finding is different from the past reports using WISC-III, as the Block Design subtest score was typically the highest of the (PRI) subtests.[8]

Other researchers have also considered the Verbal IQ (VIQ) versus Nonverbal IQ (NVIQ) profile of children with ASD and report varied findings. Some researchers have reported a NVIQ greater than VIQ pattern in children with ASD,[9,10] although other studies using different IQ tests (e.g., Differential Abilities Scales, Second Edition) have not found this pattern.[11] ASD symptomatology can also vary according to IQ levels, as children with ASD with intellectual disability are more likely to have ritualistic behaviors, social problems, or greater ASD severity overall than those without intellectual disability.[12–15]

In China, several intelligence tests for school-aged children are commonly used in the clinical settings. The Wechsler Intelligence Scale for Children, Chinese edition (WISC-C), which corresponds to the North American WISC-Revised (WISC-R), is the most widely used at the present time, given its introduction by Gong.[16] Other IQ tests include the Raven's Standard Progressive Matrices (SPM), the Raven's Color Progressive Matrices (CPM), and the Raven's Advanced Progressive Matrices (APM). The WISC-III was never introduced into China; however, the WISC-IV Chinese version is now being used more frequently,[17] although studies have not yet examined this recent version in a systematic way. According to the reports, the male-to-female ratio of ASD is about 4:1[18] The male to female ratio was 8:1 in Shanghai.[19] Further research studies examining the IQ profiles of children wish ASD are seriously needed. The current study explores the IQ profiles of school-aged boys with ASD.

The purposes of the present study included the following: (1) to explore the IQ profiles of Chinese school-aged boys with ASD using the WISC-IV Chinese version, (2) to examine the VIQ-/NVIQ profiles of Chinese school-aged boys with ASD, and (3) to determine if IQ Index scores associate with clinical symptoms of Chinese school-aged boys with ASD.

Based on prior literature, we hypothesized that (1) the children in the ASD Group (FSIQ $\geq$ 70), compared to typically developing (TD Group) children, would score significantly lower on the PSI and WMI, and their associated subtests, using the WISC-IV Chinese version; (2) children with ASD would commonly show an NVIQ > VIQ pattern; and (3) the WISC-IV Chinese version Index scores would be associated with ASD symptom scores from the Childhood Autism Rating Scale (CARS).[20]

Methods

Participants

Participants included a clinically-referred sample of consecutive cases of boys with an ASD diagnosis from the Shanghai Mental Health Center, Shanghai Jiaotong University School of Medicine between 04-01-2015 and 04-01-2016. Diagnoses were based on DSM-5[1] criteria and determined by an MD-level clinician, under the supervision of an MD/PhD Professor (Du, corresponding author).

The children in the typically developing control group (TD Group) were recruited from primary and middle schools in Shanghai. Only boys are included in this study. Children were excluded if they had any type of psychiatric disorder based on the Kiddie-SADS-Present and Lifetime Version (K-SADS-PL),[21] which was conducted by an MD-level clinician, also under the supervision of an MD/PhD Professor (Du).

This study was approved by the Shanghai Mental Health Center Ethics Committee. Parents provided written informed consent for their children. Children who were verbal and could write their name, and also judged to be capable of providing assent, signed their name on this form.

Measures

Kiddie-Schedule for Affective Disorders and Schizophrenia-Present and Lifetime Version (K-SADS-PL)[21]

The K-SADS-PL is a semi-structured diagnostic interview to assess current and past episodes of psychopathology in children and adolescents, which was designed by Kaufman et al. in 1996. The K-SADS-PL is administered by interviewing the parent(s) and the child, and achieving summary ratings which may include school interviews. In a study examining reliability and validity data, interrater reliability in scoring

screens and diagnoses were high (93–100%), and test–retest reliability kappa coefficients were in the excellent range for present and/or lifetime diagnoses of major depression, any bipolar, generalized anxiety, conduct, and oppositional defiant disorder (.77–1.0) and in the good range for present diagnoses of PTSD and ADHD (.63–.67).[21]

Autism Behavior Checklist

The Autism Behavior Checklist (ABC)[22] includes 57 items and five domains, including the Sensory, Relating, Body Concept, Language and Social Self-Help domain. It was introduced into China by Yang et al.[23] The Kappa score of the ABC is .67–.87 with the DSM-IV.[24,25] ABC has been widely used in clinical and scientific research in China.[26] It can be used with individuals aged from 18 months to 35 years, as a screening tool for ASD.

WISC-IV Chinese version

The WISC-IV Chinese version[17] is an individually administered and norm-referenced instrument designed to measure intelligence. The WISC-IV Chinese version contains 10 core subtests and five additional subtests. These are combined into four index scores and one FSIQ score, which can range from 40 to 160. Index standard scores and the FSIQ have a mean of 100 and a standard deviation of 15. Each index score is comprised of several subtests: the Verbal Comprehension Index (VCI) includes the Vocabulary (VOC), Similarities (SIM), and Comprehension (COM) subtests; the Perceptual Reasoning Index (PRI) includes the Block Design (BLD), Picture Concepts (PCn), and Matrix Reasoning (MR) subtests; the Working Memory Index (WMI) includes the Digit Span (DS) and Letter-Number Sequencing (LNS) subtests; and the Processing Speed Index (PSI) includes the Coding (CD) and Symbol Search (SYS) subtests. Summary index scores include the General Ability Index (GAI), which is the sum of the six VCI and PRI subtests, the Cognitive Proficiency Index (CPI), which is derived using the six PSI and WMI subtests, and the Full Scale IQ (FSIQ), which is based on all ten subtests. According to WISC-IV manual guidelines, VIQ is estimated by the VCI, and NVIQ is estimated by the PRI. A significant IQ discrepancy is defined as a difference between calculated VIQ and NVIQ of at least 11 points.[27] Thus, each subject can show one of the three VIQ/NVIQ patterns: NVIQ > VIQ; VIQ > NVIQ; or no significant difference between VIQ and NVIQ (i.e., VIQ = NVIQ).

Childhood Autism Rating Scale

The Childhood Autism Rating Scale (CARS)[20] is an instrument developed to assess parents' perceptions of their children's level of functioning and is comprised of 15 items that are scores based on a parent interview or clinical observation of a child's behaviors. Parents or clinicians rate each item with a score ranging from one (normal for chronological age) to four (severely abnormal). The item ratings are summed to give an overall score. Scores from 30 to 37 indicate slight to moderate abnormality; scores above 37 indicate severe abnormality. Lu et al. first used it in China, and Cronbach's alpha coefficients was 0.735, which is in the 'good' range.[28] Though the second version (CARS-2) is available in North America, this version has not yet been released in Chinese. Therefore, the current study utilized the first version of the CARS.

Procedures

The Autism Behavior Checklist (ABC) was completed by parents of the children with ASD, and scored and interpreted by an MD-level clinician working in the Shanghai Mental Health Center, Shanghai Jiaotong University School of Medicine. Parents of children in the control group also completed the Autism Behavior Checklist (ABC) after receiving instructions from the psychological professionals working in Shanghai Mental Health Center, Shanghai Jiaotong University School of Medicine. The ABC was used to rule out the presence of ASD related symptoms and behaviors. No children in the control group had elevated scores on the ABC.

The CARS was utilized for the ASD Group by an MD-level clinician, under the supervision of an MD/PhD Professor (Du) at Shanghai Mental Health Center, Shanghai Jiaotong University School of Medicine. The CARS scoring was based on information gathered from parents or caregivers as well as child observation.

Both the participants in the ASD and TD Group completed the WISC-IV Chinese version which was done by an MD-level clinician (who has been trained on the WISC-IV Chinese version administration and scoring), under the supervision of an MD/PhD Professor (Du) at Shanghai Mental Health Center, Shanghai Jiaotong University School of Medicine.

Statistical analysis

Participants' general demographic characteristics were examined and described, and an independent sample *t* test was used to analyze group differences in age, IQ Index scores and subtests. A chi-square test was used to analyze the difference between groups of various VIQ-/NVIQ patterns (i.e., VIQ > NVIQ, NVIQ > VIQ, and VIQ = NVIQ). Pearson correlation analyses were conducted to examine the association between the WISC-IV Chinese version IQ Index scores (i.e., VCI, PRI, WMI, PSI and FSIQ) and clinical ASD symptom scores on the ABC and CARS. All of the statistical analyses were performed using the Statistical Package for the Social Sciences (Version 17.0).[29] We used an alpha level of $p \leq .05$ to indicate significant results for all statistical tests.

Results

Descriptive statistics

Thirty-one children comprised the ASD Group, and 48 children comprised the TD control group. For the ASD Group, the chronological age ranged from 6 to 16 years ($M = 10.23$, $SD = 3.35$); similarly, the age range for the TD Group was 6–16 years ($M = 11.19$, $SD = 2.58$). There were no differences in regard to age ($t = -1.358$, $p = .180$) between the two groups.

Group differences

WISC-IV Chinese version index and subtest scores are summarized in Table 1. Regarding index scores, significant

Table 1 WISC-IV Chinese version: IQ differences between ASD Group and TD Group.

WISC-IV Index scores and subtests	ASD Group ($n = 31$) $M \pm SD$	TD Group ($n = 48$) $M \pm SD$	$t(77)$	p
VCI	94.71 ± 22.95	112.56 ± 14.21	−4.275	<.001
Similarities	10.77 ± 4.16	12.98 ± 2.36	−2.684	.010
Comprehension	8.10 ± 4.30	11.52 ± 3.29	−3.996	<.001
Vocabulary	8.16 ± 4.11	11.94 ± 2.44	−4.612	<.001
PRI	100.16 ± 19.78	102.71 ± 11.20	−0.653	.518
Block Design	12.29 ± 4.08	11.08 ± 2.46	1.481	.146
Picture Concepts	8.77 ± 3.26	9.96 ± 2.55	−1.803	.075
Matrix Reasoning	9.61 ± 3.71	10.48 ± 2.42	−1.151	.256
WMI	93.74 ± 19.82	98.98 ± 11.10	−1.342	.187
Digit Span	9.00 ± 3.77	9.38 ± 2.27	−.499	.621
Letter–Number Sequencing	8.55 ± 4.25	10.33 ± 2.47	−2.199	.040
PSI	88.90 ± 17.29	105.10 ± 15.06	−4.405	<.001
Coding	7.65 ± 3.22	10.92 ± 3.22	−4.408	<.001
Symbol Search	8.45 ± 3.21	10.98 ± 3.04	−3.532	.001
FSIQ	94.68 ± 20.82	106.96 ± 10.07	−3.061	.004

differences were found between the ASD Group and the TD Group for the VCI, PSI and FSIQ. No significant differences were observed for the PRI and WMI. At the subtest level, significant group differences were also present between the ASD Group and the TD Group for Similarities, Vocabulary, Comprehension, Letter-Number Sequencing, Coding and Symbol Search. Within all of these subtests the ASD Group scored lower than the TD Group. No significant differences were observed between the ASD Group and TD Group on Block Design, Picture Concepts, Matrix Reasoning and Digit Span.

VIQ-/NVIQ differences

As indicated in Table 2, in the ASD Group children showed a varied Verbal IQ (VIQ) versus Nonverbal IQ (NVIQ) profile, as 38.7% showed NVIQ > VIQ pattern, 35.5% showed VIQ = NVIQ, and 25.8% showed a VIQ > NVIQ pattern. In comparison, 47.9% of the TD Group showed a VIQ > NVIQ pattern, whereas 6.3% showed the VIQ = NVIQ pattern, and 45.8% showed a NVIQ > VIQ pattern. The comparison of the ASD Group and TD Group was statistically significant ($x^2 = 13.282$; $p = .001$).

Correlation analysis

In the ASD Group ($n = 31$), with regard the correlation with CARS scores, all the Index scores were negatively correlated with the Level & Consistency of Intellectual Response score of CARS. In turn, PSI was positively correlated with the score of Body Use (see Table 3).

Discussion

The current study examined IQ profiles among Chinese school-aged boys with ASD using the WISC-IV Chinese version and examined how the IQ Index scores were related to ASD clinical symptoms. For the ASD Group, children scored lower on the PSI than the TD Group, which is consistent with our hypothesis that children with ASD would show relative weaknesses in processing speed similar to prior results. The VCI and FSIQ were also lower in the ASD Group, compared to the TD Group. Nonetheless, no differences were found for the PRI and WMI. Examination of the VIQ/NVIQ pattern across groups revealed that the VIQ/NVIQ pattern between the ASD Group and the TD Group was significant, given that NVIQ > VIQ was observed more often in the ASD Group. The most common profile pattern in the TD Group was VIQ > NVIQ. For the total ASD sample, the IQ Index scores (i.e., VCI, PRI, WMI and FSIQ) were correlated with some of the item scores on the CARS in accordance with our predictions.

When comparing the current student to prior research the PRI and WMI were equivalent to TD children mirror those from the report of Williams et al.,[4] but differ from their findings regarding the VCI and FSIQ. The mean PRI and WMI scores within the ASD Group were similar to that of the control group, similar to Wechsler's report that PRI and WMI were equivalent for Asperger's syndrome and TD children[27];

Table 2 VIQ/NVIQ split differences between ASD Group and TD Group.

	VIQ > NVIQ n (%)	NVIQ > VIQ n (%)	VIQ = NVIQ n (%)	x^2	p
ASD Group ($n = 31$)	8 (25.8)	12 (38.7)	11 (35.5)	13.282	.001
TD Group ($n = 48$)	23 (47.9)	3 (6.3)	22 (45.8)		

Table 3 Correlation analysis of IQ Index scores and clinical symptoms in the ASD Group ($n = 31$).

	WISC-IV Chinese version				
	VCI	PRI	WMI	PSI	FSIQ
	r	*r*	*r*	*r*	*r*
Age	−0.075	0.319	.451*	0.149	0.218
CARS					
Relating to People	0.057	−0.055	−0.029	0.185	0.041
Emotional Response	−0.215	−0.018	−0.161	0.35	−0.063
Imitation	−0.206	−0.208	−0.047	−0.016	−0.192
Body Use	0.047	0.079	−0.008	.428*	0.142
Object Use	0.012	−0.078	−0.106	0.122	−0.011
Adaptation to Change	−0.042	−0.046	0.074	0.249	0.027
Listening Response	−0.119	0.106	0.03	0.316	0.103
Taste, Smell, Touch	−0.087	−0.021	0.106	0.297	−0.003
Visual Response	−0.172	0.008	−0.164	0.228	−0.054
Fear or Nervous	−0.193	−0.143	−0.275	−0.117	−0.206
Verbal Communication	−0.128	−0.315	−0.355	−0.069	−0.332
Activity Level	−0.149	0.001	−0.063	0.16	−0.007
Nonverbal Communication	0.231	−0.296	−0.152	0	−0.045
Level & Consistency of Intellectual Response	−.487*	−.476*	−.451*	−.398*	−.603**
General Impression	−0.125	−0.268	−0.314	−0.246	−0.305
Total CARS score	−0.192	−0.191	−0.209	0.184	−0.169
ABC					
Sensory	−0.043	−0.045	−0.138	0.2	0.003
Social	−0.109	0.165	−0.088	0.29	0.07
Body Concept	0.058	0.13	−0.05	0.224	0.098
Language	−0.107	−0.113	−0.15	−0.01	−0.139
Self Care	−0.047	−0.174	−0.288	−0.102	−0.147

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

however, this differs from Tang et al., who found a lower PIQ including digit symbol coding, block design, object assembly, and picture completion (which has since been replaced with PRI including Block Design, Picture Concepts, and Matrix Reasoning subtests from the WISC-IV Chinese version).[30] This difference may be due to the digit symbol coding in the PRI in WISC-C. Given that Tang used WISC-C in their study, it is not possible to compare the WMI to Tang's findings, as the WISC-C only yields the VIQ, PIQ and FSIQ. This question could be further explored in a larger sample using the WISC-IV Chinese version. For the PRI subtests, the Matrix Reasoning, Picture Concepts and Block Design scores were significantly lower in the ASD Group than the TD Group. Of the subtests in the PRI, the Block Design score was the highest for the ASD Group, which is different from Mayes and Calhoun who found that the Matrix Reasoning subtest was the highest.[6] For the WMI subtests, which measure short-term auditory memory and concentration, scores were equivalent across the ASD Group and TD Group for Digit Span and Letter-Number Sequencing.

Our findings that the ASD Group scored lower than the TD Group on VCI and FSIQ scores were similar to Tang's result. In regard to VCI subtests, ASD Group scored lowest on the Comprehension subtest, which measures social comprehension, practical judgment, and common sense.[27] These results are consistent with other reports, e.g., Allen, Lincoln and Kaufman[31] and Mayes et al.[6] The lower VCI indicates that boys with ASD are impaired in language, which is in accordance with clinical practice.

Significantly lower scores were found on the PSI and all its associated subsets (i.e., Coding and Symbol Search) when comparing the ASD Group and the TD control group. These findings highlight the processing speed weaknesses in ASD noted by Calhoun and Mayes,[32] Bardikoff and McGonigle-Chalmers,[33] and Oliveras-Rentas et al.[5] Low scores on the Coding and Symbol Search subtests in children with ASD might also indicate slower motor speed. Processing speed may contribute to the overall lower scores obtained on the WISC-IV, relative to other tests such as the Differential Abilities Scales, Second Edition (DAS-II).[34] That is, Kuriakose's suggested that children with ASD might earn higher scores on the Differential Ability Scales-Second Edition compared to the WISC-IV given that processing speed is included in the full score of the WISC-IV but not in the DAS-II.[35] Based on these results and impairment of PSI, GAI may be a better indicator of the intelligence for children with ASD instead of FSIQ.

In our investigation of the VIQ-/NVIQ profiles, we found that the most common pattern for TD Group was VIQ > NVIQ and the least common pattern was VIQ > NVIQ for the ASD Group. This finding of VIQ = NVIQ replicates a previous study by Charman et al. who reported in a sample of 156 children with ASD, the proportions of NVIQ = VIQ pattern was

58.8%, NVIQ > VIQ pattern was 28.3%, and 12.9% for the VIQ > NVIQ.[36] Tang et al. also found no significant difference between VIQ and PIQ in a high-functioning autism group in Chinese sample.[30] In the current study, the VIQ/-NVIQ pattern in the ASD Group indicates that the pattern of VIQ-/NVIQ in children with ASD may be different with TD children.

In our study, all of the index scores (i.e., VCI, PRI, WMI, PSI and FSIQ) were negatively correlated with the Level & Consistency of Intellectual Response score on the CARS; this score on the CARS is an estimation of intelligence of children from the view of their doctors. Our study found their PSI scores were positively correlated with the body use score of CARS. In CARS, the item of ''body use'' examines clumsiness, repetitive movements, poor coordination, etc. In this study, the FSIQ of children with ASD is greater or equal to 70, which indicates their hand–eye cooperation may be better, thus their processing speed may be trained. As we know, PSI has the lowest factor loading on intelligence tests, which may indicate that PSI is the most independent factor in IQ. Additionally, coding and symbol searching requires various abilities such as visual seeking, eye-hand coordination, and fine-motor skills; Kaufman has pointed out that PSI can be negatively impacted by these neurological variables.[37] Nonetheless, whether the impairment of PSI causes more ASD related symptoms requires further investigation. According to Mayes and Calhoun,[15] children with low IQs (IQ < 80) had more autistic symptoms overall and a greater percentage of social problems than children with high IQs (IQ $\geq$ 80), but when the effects of IQ and age were statistically removed, these differences were no longer significant. In our study, less symptoms are correlated with the IQs, which may be due to the reason that all the participants with FSIQ $\geq$ 70.

Limitations

Our study includes several limitations, including a relatively small sample size for the ASD Group. A small sample size may negatively impact results, due to low statistical power. Additionally, an age range from 6 to 16 years old may impact the results due to differences in development with such a large range. Thus, further studies should examine the possible differences that may arise when breaking students into younger versus older groups. Additionally, this study only included boys, thus we did not compare the IQ profile between boys and girls with ASD. Lastly, the scales utilized for the ASD related symptoms are outdated when compared to current scales used in North America, but at present, they are still widely used in China.

Conclusions

Using the WISC-IV Chinese version we found that scores of VCI, PSI and FSIQ in ASD boys were lower, but PRI and WMI scores were equivalent to TD boys. Our findings also indicate that children in the ASD Group exhibit different patterns of VIQ and NVIQ scores from the TD Group. In addition, we found that some of the IQ Index scores were negatively correlated with the ASD symptoms. Future studies could explore the gender differences[38] and the relationship between IQ profiles and clinical symptoms.

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