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Comparison of the cognitive profiles and social adjustment between mathematically and scientifically talented students and students with Asperger's syndrome

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ABSTRACT

This study compared the cognitive profiles and social adjustment of mathematically and scientifically talented (MST) students and students with Asperger's syndrome (AS) as compared to typically developing students. The applied instruments were the Wechsler Adult Intelligence Scale, 3rd version, Me Scale II, Social Responsiveness Scale (SRS), Adult Autism Spectrum Quotient (AQ), and autism diagnostic interview-revised. Eighty-four male students, aged 16–26, were assigned to four groups according to a talent in mathematics and science, diagnosis of AS, and the IQ level. The results showed that the high-IQ MST group exhibited balanced development in cognitive and affective aspects, the average-IQ MST group demonstrated weakness in perceptual organization and working memory, and problems with social awareness and socialness, and the AS group had weakness in performance IQ, particularly in digit symbol-coding and symbol search and a wide-range of autistic-like social deficits (SRS) and autistic trait (AQ), and reported lower empathetic and higher emotional and creative overexcitability. Our findings support differential cognitive profiles and social adjustment between the MST and AS groups, and the influence of IQ on these manifestations in MST students. More attention should be paid to the social difficulty of average-IQ MST students in addition to AS students.

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1. Introduction

Mathematically and scientifically talented (MST) students constitute the highest percentage of academically talented students in Taiwan. They are successful in international mathematics and science competitions and have exceptional academic achievements. Most of them enroll in the departments of medicine, physics, and engineering at prestigious universities in Taiwan. How these students differ from other students regarding brain structures and functioning has been an intriguing question and has drawn much more attention in recent decade in many countries and Taiwan as well. Kuo et al. (2012) applied magnetic resonance imaging (MRI) techniques and determined that senior high school students talented in mathematics and science, compared with their typically developing (TD) peers, possessed a lower volume of gray matter in the somatosensory-related cortical region (BA 40), which is associated with empathy and interpersonal perception (Kuo et al., 2012; Peelen & Downing, 2007). Based on their findings, educators are recommended to pay more attention to these students' social ability and adjustment than just academic performance (Kuo et al., 2012); further research to distinguish these students from those with Asperger's syndrome (AS) and a talent in science is warranted.

In England, a study addressing the association between AS and mathematical and scientific skills was conducted (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). Using the Autism-Spectrum Quotient (AQ), compared students studying the sciences, humanities, and social sciences, and observed an association between scientific and mathematical skills and autistic conditions (Baron-Cohen et al., 2001), they observed that mathematicians scored the highest and the Mathematics Olympiad winners scored significantly higher than the male humanities students at Cambridge University. Similarly, Liu reported that medical school students who attended gifted and talented classes in high school or college students who participated in the International Mathematics Olympiad scored significantly higher than students of the sciences and humanities, and TD college students (Liu, 2008).

The aforementioned research prompted us to compare the cognitive profiles, and social adjustment between MST students and students with AS as compared to TD students.

2. Literature review

2.1. Gifted and talented students

Among several definitions of gifted and talented students, the definition of Gagné (2000) has been widely applied. Gagné (2000) distinguished "giftedness" and "talent" as follows: "The term "giftedness" designates the possession and use of untrained and spontaneously expressed natural abilities (called aptitudes or gifts) in at least one ability domain, to a degree that places an individual among the top 10% of same-age peers) [and] the term "talent" designates the superior mastery of systematically developed abilities (or skills) and knowledge in at least one field of human activity, to a degree that places an individual within the top 10% of age peers who are (or have been) active in that field (p. 67)" (Gagné, 2000).

In Taiwan, students with high IQ scores (2 standard deviations, SD, above mean IQ) are labeled as students with general intelligence (or giftedness), and students who may not possess high IQs but perform excellently in certain areas, such as mathematically talented students or artistically talented students, are called "talented students." Thus, in a gifted and talented class, some students may innately possess superior intelligence and great talents, whereas others may not possess high IQs but demonstrate exceptional talents.

Gifted and talented students generally display broader interests and exhibit superior learning abilities in a wide range of domains like cognitive, social, emotional, and linguistic domains (Davis & Rimm, 1998; Gallagher, 1985; Lewis, 1943; Robinson & Noble, 1991). Of them, cognitive ability has long been the focus of educators of gifted students, they enjoyed learning and asking questions and demonstrated a long-lasting attention span on the tasks of interest (Baska, 1989; Blackburn & Erickson, 1986; Clark, 1992; Piirto, 1994). Moreover, gifted students possessed a higher level and higher quality of creativity, imagination, and divergent thinking (Silverman, 1990).

In addition to excellent academic performance, in recent decades, psychologists and educators have continued exploring the psychological traits of gifted and talented people. Regarding emotional traits, several studies have shown that gifted students were emotionally oversensitive (Altman, 1983; Clark, 1992; Cross, 1996; Larsen, Diener, & Emmons, 1986), sympathetic, passionate, and compassionate (Lovecky, 1992, 1993; Mendaglio, 1998; Silverman, 1983, 1993), and demonstrated perfectionism (Blackburn & Erickson, 1986; Buescher, 1985; Clark, 1992; Davis & Rimm, 1998; Lewis, Kitano, & Lynch, 1992; Parker, 1997; Roedell, 1984; Roeper, 1982; Whitmore, 1980). Concerning the personality traits of gifted students, Dabrowski (Dabrowski, 1938; Miller, Silvermany, & Falk, 1995; Silverman, 1993) indicated five dimensions of heightened psychological responses presented by gifted and talented students: psychomotor (POEs; pressure for action), sensual (SOEs; sensate pleasures), imaginational (MOEs; active imagination), intellectual (TOEs; intellectual and moral pursuits), and emotional overexcitabilities (EOEs; intense connectedness with others).

According to Dabrowski's theory, overexcitabilities are crucial factors in emotional development that the more significant overexcitabilities a person presents, the higher the level of emotional development a person could achieve (Dabrowski, 1964). In addition, gifted and talented people were more inclined to demonstrate overexcitability traits than their counterparts (Dabrowski, 1964). This proposition has been tested in earlier (Dabrowski, 1970) and recent (Chang & Kuo, 2013) studies showing that gifted students exhibited various neurotic symptoms like nervousness, anxiety, depression, tics, and various forms of overexcitability, whereas students with mental retardation did not have these symptoms.

In Taiwan, relevant research reported that elementary school students scored high in MOE and TOE (Chang, 2001; Lin, 2003; Tsai, 2006); junior and senior high school gifted and academically talented students scored high in TOE, MOE, SOE, and EOE (Chang, 2001, 2003; Huang, 2005; Xie, 2005); and undergraduate students from electrical engineering departments scored high in only TOE and EOE (Kuo & Chang, (unpublished)). Furthermore, Chang (2011) found that MOE and creative OEs were positively associated with creative personality, and EOE was associated with psychosocial maladjustment with high correlations (Chang, 2011). The later was further supported by a latest evidence of positive relationship between EOE and psychological maladjustment (Chang & Kuo, 2013).

2.2. Autism spectrum disorder

Autism Spectrum Disorder (ASD) consists of autistic disorder, Asperger's disorder (Asperger's syndrome in ICD-10), and pervasive developmental disorder, not otherwise specified based on the Diagnostic and Statistical Manual of Mental Disorders 4th edition (DSM-IV) diagnostic criteria. Based on the DSM-IV, among the three core symptoms of ASD (deficit in communication and social reciprocity, stereotyped/restricted behaviors, and social deficit), social deficit has been considered the primary autistic feature (Baron-Cohen, 2004).

The latest DSM version, DSM-5 (American Psychiatric Association, 2013), defines two core symptoms of ASD by combining the first two core symptoms as a socio-communication deficit with the original stereotyped/restricted behaviors. The diagnoses of Asperger's disorder and autistic disorder are no longer used in the current DSM-5 version.

The etiology of ASD remains unknown. However, research on brain anatomy provides few possible clues to explain the atypical development in social interaction, communication, and behavior of people with ASD. Studies conducted using neuropsychological tests and functional MRI techniques have proposed several theories, including the (a) weak central coherence theory (Happé & Frith, 1996), which suggests that people with ASD think locally rather than globally; (b) extreme male brain theory (Baron-Cohen, 2002), which explains the inadequacy in or lack of empathy; and (c) mirror neuron system theory (e.g., Dapretto et al., 2005), which indicates the poor imitation skills of people with ASD.

Cognitive profiles have been analyzed repeatedly in people with AS and high-functioning autism (HFA). A higher verbal IQ than performance IQ as well as a lack of language delay is more likely to be observed in people with AS than in people with HFA; however, the results are inconsistent (Ghaziuddin & Mountain-Kimchi, 2004; Gilchrist et al., 2001; Koyama, Tachimori, Osada, Takeda, & Kurita, 2007; Noterdaeme, Wriedt, & Höhne, 2010; Ozonoff, Rogers, & Pennington, 1991; Ozonoff, South, & Miller, 2000; Saulnier & Klin, 2007; Szatmari, Bartolucci, & Bremner, 1989).

Ehlers et al. (1997) assessed 120 children with AS, autistic disorder, and attention disorders with the revised Wechsler Intelligence Scale for Children-Revised (WISC-R) and found that individuals with autistic disorder were characterized by a peak in block design, children with AS demonstrated excellent verbal ability and difficulty with object assembly and coding, and children with attention disorders had difficulty with coding and arithmetics. Joseph, Tager-Flusberg, and Lord (2002) reported that the discrepancy between verbal IQ and performance IQ was influenced not only by overall IQ but also age and social functions in ASD. However, studies comparing IQ and cognitive profiles between AS children and HFA children have revealed inconsistent findings (Planche and Lemonnier, 2012). Convergent evidence from several studies supports lower verbal IQ than performance IQ in HFA and higher verbal IQ than performance IQ in AS (Ghaziuddin & Mountain-Kimchi, 2004; Kaland et al., 2002; Mottron, 2004; Planche and Lemonnier, 2012; Volkmar, Paul, Klin, & Cohen, 2005). Noterdaeme et al. (2010) also observed that with a higher verbal IQ, AS children exhibited a higher full-scale IQ than HFA children.

2.3. Autism spectrum disorder and talent

In an article entitled *Autism as Academic Paradigm*, Cowen mentioned that many people at colleges are aware of the autism spectrum than most people realize (Cowen, 2009). He specified that: "Autism is often a competitive advantage rather than a problem to be solved. . .. In spite of some of the harmful rhetoric, the on-the-ground reality is that autistics have been very good for colleges, and colleges have been very good for autistics."

Although some students with high-functioning ASD may easily excel in mathematics and science and enroll at prestigious schools or in educational programs, they are still prone to social deficits. These deficits include a lack of empathy, ability to control emotions, and social interest as well as insensitivity to social cues, leading to difficulties in forming or maintaining friendships (Vuilleumier & Pourtois, 2007). Their amygdala and brain regions associated with social functions display varying pattern activations compared with their TD peers in processing social stimuli (Vuilleumier & Pourtois, 2007). In *Autism and Talent*, Happé and Frith stated three possible explanations for the association between ASD and talents: First, people with AS might free up mental and time resources used in tracking and remembering social content to develop their talent (Happé & Frith, 2010). Second, difficulty in tracking others' mental states may contribute to the originality demonstrated in developing a talent; that is, they are more likely than TD to concentrate on their own thoughts and interest without knowing what others think. Third, mind-blindness of a person's own mind may be attributable to developing a talent.

2.4. Research questions

Based on literature review, the authors' question whether students talented with mathematics and science exhibit similar social deficits to students with AS; whether differences in cognitive profiles among mathematically and scientifically

talented (MST) students, AS students and TD students exist; and whether MST students with varying IQs display different cognitive profiles and social adjustment.

3. Methods

3.1. Participants

In the fall of 2011, 84 (80.8%) students of 104 recruited students were included in the final sample of this study because they completed all the assessments. These 84 participants, aged 16–26, were male senior high school and university students. They were assigned to the four comparison groups according to whether they were MST or TD students, with or without AS. Such assignment yielded the high-IQ MST (MSTHIQ, $n = 24$), average-IQ MST (MSTAIQ, $n = 17$), AS ($n = 14$), and TD groups (TD, $n = 29$), and the mean ages (SD) for the four groups were 18.63 (SD = 1.58), 19.82 (SD = 1.74), 17.93 (SD = 2.06), and 20.07 (SD = 1.51), respectively.

3.1.1. Mathematically and scientifically talented (MST) students with a high IQ

Twenty-four participants were recruited from the department of science ($n = 1$), department of electrical and computer engineering ($n = 2$), department of computer science ($n = 7$), department of medicine ($n = 1$), department of life science ($n = 1$), and department of bioresources and agriculture ($n = 1$) of Taiwanese universities and from top-talent mathematics and science classes in senior high schools ($n = 11$). To ensure their exceptional competencies in mathematics and science, those students who were identified as MSTHIQ students must have studied or have been studying in a class of mathematics and science in senior high schools and scored above the 97th percentile on the WAIS-III.

3.1.2. Mathematically and scientifically talented students with an average IQ

Seventeen participants were recruited from the department of science ($n = 1$), department of engineering ($n = 3$), department of electrical and computer engineering ($n = 2$), department of computer science ($n = 6$), department of medicine ($n = 1$), department of life science ($n = 1$), and department of bioresources and agriculture ($n = 1$) of Taiwanese universities and from top-talent mathematics and science classes in senior high schools ($n = 2$). To ensure their exceptional competencies in mathematics and science, students who were identified as MSTAIQ students must have studied or have been studying in a class of mathematics and science in senior high school and scored above average but below the 97th percentile on the WAIS-III.

3.1.3. Students with Asperger's syndrome

Fourteen participants had a clinical diagnosis of AS according to the DSM-IV diagnostic criteria and were further confirmed by the autism diagnostic interview-revised (ADI-R) interview by the corresponding author, a board-certified psychiatrist, at National Taiwan Hospital.

3.1.4. Typically developing (TD) students

Twenty-nine participants without clinical diagnosis of ASD, who were university or high school students, who had never studied in the gifted and talented classes, and whose IQ scores were below the 97th percentile on the WAIS-III, were recruited into the study.

3.2. Measures

3.2.1. Wechsler Adult Intelligence Scale, 3rd edition (WAIS-III)

The Wechsler Adult Intelligence Scale (WAIS) is a test designed for measuring intelligence in adults and older adolescents aged 16 up to 89. The WAIS-III, a subsequent revision of the WAIS and the WAIS-R, was released in 1997.

The WAIS-III-Chinese version was developed in Taiwan in 2002 (Chen & Chen, 2002) and provides scores for verbal IQ (VIQ), performance IQ (PIQ), and full scale IQ (FSIQ), along with four secondary indices: (1) Verbal Comprehension Index (VCI): including information, similarities, and vocabulary tests; (2) Working Memory Index (WMI): arithmetic and digit span; (3) Perceptual Organization Index (POI): including block design, matrix reasoning, and picture completion; and (4) Processing Speed Index (PSI): digit symbol-coding and symbol search. VIQ includes seven tests: five included in the two sub-indices (VCI and WMI) and two not included (letter-number sequencing and comprehension). PIQ includes seven tests: five include in the POI and PSI and two not included (picture arrangement and object assembly).

3.2.2. The Chinese version of the autism diagnostic interview-revised (ADI-R)

The ADI-R (Lord, Rutter, & Le Couteur, 1994) is a standardized, comprehensive, semistructured, and investigator-based interview for caregivers. The ADI-R covers the majority of the developmental and behavioral aspects of ASD, including reciprocal social interaction, communication, repetitive behaviors, and stereotyped patterns, for children with a mental age from approximately 18 months to adulthood. Gau and colleagues prepared the Chinese version of the ADI-R (Chien, Gau, Chen et al., 2013; Chien, Gau, Liao et al., 2013; Chou et al., 2012; Gau et al., 2011), which was approved by the Western Psychological Services (WPS) in May 2007 for the use in this study.

3.2.3. The Me Scale II

The Me Scale II (Chang, 2011), a 62-item self-administered questionnaire, was revised from the Me Scale (Chang, 2001). The Me Scale (60 items) was originally constructed to assess over-excitabilities (OEs) (Dabrowski, 1938). Items are rated as a 7-point Likert scale (ranging from 1 for not very significant to 7 for very significant). A high score indicates stronger OE. Dabrowski stated that some gifted children, adolescents, and even adults consistently overreacted to internal and external stimulation. Therefore, he named the traits "over-excitabilities", which include psychomotor, sensual, intellectual, imaginational, and emotional over-excitabilities.

To explore the effect of over-excitabilities on learning and social adjustment, each of the original five OE 5 subscales were further extended to include two dimensions that are either associated with positive or negative school adjustment in the Me Scale II. The 10 subscales are psychological (Psy OE), physical (Phy OE), sensually sensitive (Sen OE), sensually pleasurable (Spl OE), intellectual (Itl OE), perfectionism (Pfc OE), creative (Crt OE), imaginational (Img OE), empathetic (Emp OE), and emotional (Emo OE) over-excitabilities. The sample questions for each of the 10 subscales are provided in supplemental Table 1. The internal consistency of this version was high (Cronback's alpha values of 10 subscales ranging from 0.70 to 0.86; alpha of total scale, 0.94). The Pearson's correlations for test–retest reliability ranged from 0.59 to 0.80 (Chang, 2011; Chang & Kuo, 2013).

3.2.4. The Chinese version of the social responsiveness scale (Chinese SRS)

The original social responsiveness scale (SRS) was developed by Constantino, Davis et al. (2003) and Constantino, Hudziak, and Todd (2003). The scale consists of 65 social behavior descriptions without any judgmental overtones (Constantino, 2005). The SRS was designed as a self- or caregiver-reported 4-point Likert-type questionnaire regarding the frequency of each behavior (0 for never true and 3 for always true) for quantifying autistic traits. A high score indicates severe social dysfunction.

The Chinese SRS was revised by the Taiwan Autism Study Group that was led by Gau and Wu, using the standard two-way translation-backtranslation procedure (Harkness & Schoua-Glusberg, 1998) with permission from Dr. Constantino and with the approval of WPS in 2008. The Chinese SRS consists of 60 items that are structured into four factors (i.e., sociocommunication, autism mannerisms, social awareness, and social emotion). The 4-week test–retest reliability (intra-class correlations 0.75–0.85), internal consistency (Cronbach's alpha 0.94–0.95), and convergent validity with the Chinese SCQ (Gau et al., 2011; Pearson correlations 0.61–0.87,) demonstrated well-accepted psychometric performance and a reliable and valid instrument for measuring autistic traits in the ethnic Chinese population of Taiwan (Gau, Liu, Wu, Chiu, & Tsai, 2013).

3.2.5. The Chinese version of the adult autism-spectrum quotient (AQ)

The adult autism-spectrum quotient (AQ) was developed by the Autism Research Center, University of Cambridge (1998) and was revised in Taiwan by the corresponding author and colleagues (Lau et al., 2013). The original AQ is a self-report questionnaire developed for quantifying autistic traits in adults with normal intelligence. The questionnaire consists of 50 theoretically derived statements depicting personal views, habits, and preferences pertinent to the unique profile of ASD. Two sample items are, "other people frequently tell me what I have said is impolite, even though I think it is polite" and "I am good at social chit-chat." To avoid response bias, approximately half of the statements were reversal items.

The Chinese version of the AQ was designed to be short, simple to use, and simple to score, particularly for self-report by adults with an IQ in the average range or above. This version of the AQ comprises 35 items with 5-dimensional factors. The subscales of this novel AQ-Chinese version, namely socialness, mindreading, patterns, attention to detail, and attention switching, were statistically and semantically coherent. In this study, we first employed an ordinal (4-point Likert) scale (ranging from 1 to 4 for items portraying autistic features, and inverted for the reversed items) instead of the original dichotomous scale for responses to the AQ to obtain an approximate continual distribution to provide additional information for procedures such as factor analysis (Gorsuch, 1983; McLeod, Swygert, & Thissen, 2001). Each statement was rated on a 4-point scale, with answer categories definitely agree, slightly agree, slightly disagree, and definitely disagree. Each response of definitely agree or slightly agree that indicated an autistic feature was scored a 1, and a 0 was scored if the response was slightly disagree or definitely disagree, leading to a total score of the AQ, ranging from 0 to 35 (high scores indicated the autistic end of the continuum).

3.3. Procedures

The Taipei Medical University-Joint Institutional Review Board approved this study before implementation (Approval No.: 201103014). All the participants and their parents were informed of the objectives and procedures of the study, including confidentiality and the voluntary participation of this study. All the participants and their parents if participants were younger than 20 years old provided written informed consent before study implementation.

The parents of students with ASD completed the ADI-R interview at a laboratory of the National Taiwan University Hospital, and all of the parents reported their child's autistic-like social deficits on the SRS and student participants completed IQ tests (WAIS-III) and reported on the Me Scale II, and AQ at the Department of Special Education, National Taiwan Normal University.

3.4. Data processing and analysis

Data analysis was conducted by using the SPSS Win 20.0 program (SPSS Inc., Chicago). Because the participants of the four comparison groups (i.e., MSTHIQ, MSTAIQ, AS, TD) were not matched, we compared the mean scores of all the measures (continuous variables) based on normative scaled scores calculated using an analysis of variance. Scheffe's test was used for the adjustment for multiple comparisons in the post hoc analyses.

4. Results

4.1. Group differences in the IQ profiles

Table 1 presents the significant group variations in the IQ profiles. The high-IQ MST group had the highest score for all the IQ profiles among the four groups ($p < 0.001$) except the VCI and PSI scores, in which there were no significant differences between the high-IQ MST and average-IQ MST groups. In general, there were no significant differences in IQ profiles among the other three groups with the following exceptions. The AS group had lower PIQ and PSI than the TD group and had lower FSIQ, PIQ, and PSI than the average-IQ MST group (Table 1 and Fig. 1).

Table 1
Group comparisons of IQ profiles.

	Mean	SD	*F*-test	Post Host (Scheffe's)
Full-Scale IQ				
MSTHIQ	135.08	4.30	39.33***	MSTHIQ > MSTAIQ ($P < 0.001$)
MSTAIQ	120.76	6.33		MSTHIQ > TD ($P < 0.001$)
TD	114.48	5.63		MSTHIQ > AS ($P < 0.001$)
AS	110.07	15.79		MSTAIQ > AS ($P < 0.01$)
Total	120.90	12.45		
Verbal IQ				
MSTHIQ	133.46	7.71	19.15***	MSTHIQ> MSTAIQ ($P < 0.01$)
MSTAIQ	122.59	8.72		MSTHIQ > TD ($P < 0.001$)
TD	114.34	6.49		MSTHIQ > AS ($P < 0.001$)
AS	115.14	17.32		
Total	121.61	12.59		
Performance IQ				
MSTHIQ	130.17	9.31	27.38***	MSTAIQ > AS ($P < 0.01$)
MSTAIQ	115.65	7.17		MSTHIQ > MSTAIQ ($P < 0.001$)
TD	112.93	9.62		MSTHIQ > TD ($P < 0.001$)
AS	102.36	12.58		MSTHIQ > AS ($P < 0.001$)
Total	116.64	13.50		TD > AS ($P < 0.05$)
Working Memory Index				
MSTHIQ	130.17	10.10	18.06***	MSTHIQ > MSTAIQ ($P < 0.01$)
MSTAIQ	116.24	9.05		MSTHIQ > TD ($P < 0.001$)
TD	107.48	8.96		MSTHIQ > AS ($P < 0.001$)
AS	107.00	21.44		
Total	115.65	15.49		
Verval Comprehension Index				
MSTHIQ	130.33	8.23	8.30***	MSTHIQ > TD ($P < 0.001$)
MSTAIQ	121.76	7.75		MSTHIQ > AS ($P < 0.01$)
TD	117.21	8.26		
AS	118.07	17.02		
Total	122.02	11.38		
Perceptual Organization Index				
MSTHIQ	129.58	9.74	15.49***	MSTHIQ > MSTAIQ ($P < 0.01$)
MSTAIQ	115.71	6.60		MSTHIQ > TD ($P < 0.001$)
TD	111.83	11.09		MSTHIQ > AS ($P < 0.001$)
AS	108.50	16.04		
Total	117.13	13.57		
Processing Speed Index				
MSTHIQ	125.42	12.22	19.49***	MSTAIQ > AS ($P < 0.001$)
MSTAIQ	116.82	13.48		MSTHIQ > TD ($P < 0.01$)
TD	110.52	13.76		MSTHIQ > AS ($P < 0.001$)
AS	90.79	16.29		TD > AS ($P < 0.01$)
Total	112.76	17.74		

MSTHIQ, mathematically and scientifically talented students with high-IQ; MSTAIQ, mathematically and scientifically talented students with average-IQ; TD, typically developing students; AS, students with Asperger's syndrome.
*** $P < 0.001$.

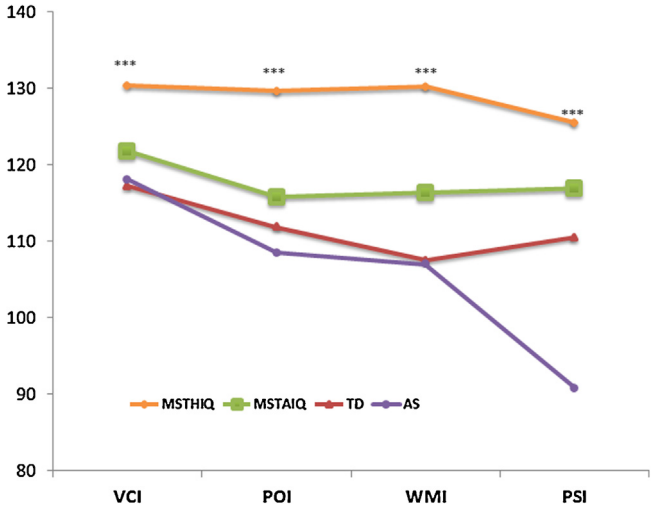

Fig. 1. Profiles of four subscales of the WAIS-III for the four groups. Notes: MSTHIQ, mathematically and scientifically talented students with high-IQ, MSTAIQ, mathematically and scientifically talented students with average-IQ, TD, typically developing students, AS, students with Asperger's syndrome, VCI, verbal comprehension index, POI, perceptual organization index, WMI, working memory index, PSI, processing speed index, *** all four group comparisons at p values $<$ 001 level.

With regards to the group comparisons of the 14 subscales of the WAIS-III (see Fig. 2 and Supplemental Table 2), in general, there were no significant group variations in the similarities, picture completion, and object assembly among the four groups. The MSTHIQ scored the highest in the arithmetic, digit span, and block design subscales. The MSTHIQ scored significantly higher than the AS and TD groups in the vocabulary, information, comprehension, letter-number sequencing, matrix reasoning, picture arrangement (>AS only), digit symbol-coding, and symbol search. Moreover, the MSTAIQ scored higher than the AS group in the comprehension, digit symbol-coding, and symbol search. The only difference between the AS and TD groups was lower score in symbol search in AS.

Despite higher IQ scores and indices in the MSTHIQ group than the other three groups, the IQ distribution patterns of the MSTHIQ, MSTAIQ, and TD groups were similar (Figs. 1 and 2). In contrast, the IQ distribution demonstrated an uneven pattern in the AS group, which obtained the lowest score in digit symbol-coding, symbol search, and comprehension. Besides, students with AS had significantly lower PSI than the other three groups with lower mean PIQ (102.36 ± 12.58) than VIQ (115.14 ± 17.32, paired t-test = -3.99, $p < 0.01$) (Table 1).

4.2. Group variations in over-excitability profiles

For the ten over-excitability, in general, there were no significant group differences with the following exceptions (Table 2). The AS group reported significantly stronger emotional over-excitability than the MST group ($p < 0.05$) and

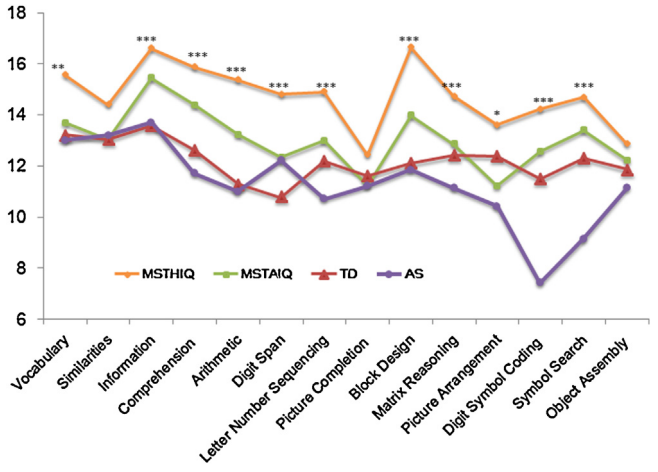

Fig. 2. Profiles of the 14 subscores of the WAIS-III of the four groups. Notes: MSTHIQ, mathematically and scientifically talented students with high-IQ, MSTAIQ, mathematically and scientifically talented students with average-IQ, TD, typically developing students, AS, students with Asperger's syndrome; Four group comparisons: $^{*}p$ values $<$ 05, $^{**}P < 0.01$, $^{***}P < 0.001$.

Table 2
Group comparisons of subscales of the over-excitabilities scale.

	Group	Subtest		Item		*F*-test	Post host (Scheffe)
		Mean	SD	Mean	SD		
Psychological over-excitabilities	MSTHIQ	28.21	7.07	4.70	1.18	2.17	
	MSTAIQ	29.82	8.05	4.97	1.34		
	TD	29.10	5.69	4.85	0.95		
	AS	24.21	6.09	4.04	1.02		
	Total	28.18	6.83	4.70	1.14		
Physical over-excitabilities	MSTHIQ	14.83	5.78	3.71	1.44	2.38	
	MSTAIQ	14.94	4.72	3.74	1.18		
	TD	14.24	4.55	3.56	1.14		
	AS	18.64	6.18	4.66	1.55		
	Total	15.29	5.37	3.82	1.34		
Sensually sensitive over-excitabilities	MSTHIQ	20.38	4.50	4.08	0.90	0.83	
	MSTAIQ	22.29	5.44	4.46	1.09		
	TD	22.38	5.54	4.48	1.11		
	AS	21.29	4.30	4.26	0.86		
	Total	21.61	5.03	4.32	1.01		
Sensually pleasurable over-excitabilities	MSTHIQ	27.54	5.80	4.59	0.97	1.99	
	MSTAIQ	28.24	4.54	4.71	0.76		
	TD	29.83	4.71	4.97	0.79		
	AS	26.00	5.23	4.33	0.87		
	Total	28.21	5.19	4.70	0.87		
Intellectual over-excitabilities	MSTHIQ	35.96	6.59	5.14	0.94	1.73	
	MSTAIQ	33.82	5.71	4.83	0.82		
	TD	31.83	7.04	4.55	1.01		
	AS	33.50	6.61	4.79	0.94		
	Total	33.69	6.68	4.82	0.95		
Perfectionism over-excitabilities	MSTHIQ	29.79	4.18	4.97	0.70	0.75	
	MSTAIQ	28.35	4.12	4.73	0.69		
	TD	30.14	4.20	5.02	0.70		
	AS	28.86	4.99	4.81	0.83		
	Total	29.46	4.30	4.91	0.72		
Creative over-excitabilities	MSTHIQ	46.92	7.56	5.21	0.84	3.67*	AS > TD ($P < 0.05$)
	MSTAIQ	44.35	7.78	4.93	0.86		
	TD	41.59	8.91	4.62	0.99		
	AS	49.29	6.32	5.48	0.70		
	Total	44.95	8.30	4.99	0.92		
Imaginational over-excitabilities	MSTHIQ	28.83	7.87	4.12	1.13	1.98	
	MSTAIQ	28.41	7.91	4.06	1.13		
	TD	28.24	8.21	4.03	1.17		
	AS	34.00	6.47	4.86	0.92		
	Total	29.40	7.93	4.20	1.13		
Empathetic over-excitabilities	MSTHIQ	24.42	3.83	4.88	0.77	2.67*	
	MSTAIQ	23.76	3.96	4.75	0.79		
	TD	25.45	4.20	5.09	0.84		
	AS	21.71	4.67	4.34	0.93		
	Total	24.19	4.25	4.84	0.85		
Emotional over-excitabilities	MSTHIQ	23.67	7.28	3.38	1.04	3.82*	AS > MSTHIQ ($P < 0.05$)
	MSTAIQ	27.65	7.06	3.95	1.01		
	TD	26.76	8.85	3.82	1.26		
	AS	32.57	7.63	4.65	1.09		
	Total	27.02	8.27	3.86	1.18		

MSTHIQ, mathematically and scientifically talented students with high-IQ; MSTAIQ, mathematically and scientifically talented students with average-IQ; TD, typically developing students; AS, students with Asperger's syndrome.
* $P < 0.05$.

stronger creative over-excitability than the TD group ($p < 0.05$). Although there was significant group differences in the empathetic OE score ($p < 0.05$), such statistical significance did not remain after adjusting for multiple comparison.

4.3. Group variations in autistic-like social deficits assessed by the SRS

Table 3 shows the results of the group variations in the parental report on the SRS about the participants. The AS group demonstrated significantly higher total SRS score, and sociocommunication and autism mannerisms sub-scores, than the

Table 3
Group comparisons of the subscores and total score of the social responsiveness scale.

	Group	Mean	SD	*F*-test	Post Host (Scheffe)
Sociocommunication	MSTHIQ	21.04	11.17	9.58***	AS > MSTAIQ ($P < 0.01$)
	MSTAIQ	21.06	11.00		AS > MSTHIQ ($P < 0.001$)
	TD	21.45	11.51		AS > TD ($P < 0.001$)
	AS	39.86	14.61		
	Total	24.32	13.60		
Autism mannerisms	MSTHIQ	10.21	7.09	6.20**	AS > MSTAIQ ($P < 0.05$)
	MSTAIQ	11.35	5.07		AS > MSTHIQ ($P < 0.01$)
	TD	11.45	6.29		AS > TD ($P < 0.01$)
	AS	18.64	5.23		
	Total	12.27	6.71		
Social awareness	MSTHIQ	11.38	4.71	8.45***	AS > MSTHIQ ($P < 0.01$)
	MSTAIQ	14.06	5.18		AS > TD ($P < 0.001$)
	TD	10.90	4.20		
	AS	17.57	3.32		
	Total	12.79	5.00		
Social emotion	MSTHIQ	8.13	4.60	2.01	
	MSTAIQ	9.00	4.36		
	TD	9.52	4.43		
	AS	11.79	4.59		
	Total	9.39	4.57		
Total score	MSTHIQ	50.75	25.19	9.00***	AS > MSTAIQ ($P < 0.01$)
	MSTAIQ	55.47	21.83		AS > MSTHIQ ($P < 0.001$)
	TD	53.31	21.49		AS > TD ($P < 0.001$)
	AS	87.86	24.24		
	Total	58.77	26.26		

MSTHIQ, mathematically and scientifically talented students with high-IQ; MSTAIQ, mathematically and scientifically talented students with average-IQ; TD, typically developing students; AS, students with Asperger's syndrome.
** $P < 0.01$.
*** $P < 0.001$.

other three groups (see Table 3). Moreover, the AS group scored significantly higher in social awareness than the high-IQ MST group and the TD group; however, no significant difference was found between the AS and the average-IQ MST groups. There were no significant differences in social emotion among the four groups.

4.4. Group variations in autistic traits assessed by the AQ

Table 4 presents the group differences in the total and subscale scores of self-reported autistic traits assessed by the AQ. The results showed that the AS group reported highest total score and mindreading subscale score among the four groups. In addition, the AS group scored higher than the MSTAIQ group in the subscale of socialness and attention switching (see Table 4).

5. Discussion

As one of few studies comparing the cognitive profiles and social adjustments related to autistic traits in MST students as compared to AS and TD students, we found different cognitive profiles and autistic-like social deficits among MST, AS, and TD students. The MSTHIQ students performed well in cognitive and psychosocial assessments, displaying balanced development; on the other hand, the students with AS had higher VIQ than their PIQ scores, and overt social impairment.

5.1. Cognitive profiles and social interaction of the high-IQ MST group

Our results indicated that the MSTHIQ students performed well in cognitive and psychosocial assessments, displaying a balanced development in cognitive and affective aspects, which is relevant to literature reports (Davis & Rimm, 1998; Gallagher, 1985; Lewis, 1943; Lovecky, 1992, 1993; Mendaglio, 1998; Piirto, 1994; Robinson & Noble, 1991). These high-IQ students tended to have highest intellectual OE and perfectionism and lowest emotional OE, though not reaching statistically significant level (Table 2). Hence, our results based on young adults did not lend evidence to support previous studies that have used samples from gifted and academically talented elementary school and high school students (Chang, 2001, 2003; Huang, 2005; Kuo & Chang, (unpublished); Tsai, 2006; Xie, 2005). The differential findings probably can be explained by that the MSTHIQ group came from well-known universities and senior high school gifted classes, they were all high achievers and involved with the mathematics and science departments or mathematically and scientifically talented classes; thus, because these students are more logical and have calmer minds, the excitability traits may be controlled effectively.

Table 4
Group comparisons of the subscores and total score of the Adult Autism-Spectrum Quotient scale.

	Group	Mean	SD	*F*-test	Post host (Scheffe)
Socialness	MSTHIQ	3.13	3.06	3.64*	AS > MSTHIQ ($P < 0.05$)
	MSTAIQ	4.75	3.51		
	TD	3.93	3.47		
	AS	6.64	2.90		
	Total	4.31	3.43		
Mindreading	MSTHIQ	1.42	1.95	14.21***	AS > MSTAIQ ($P < 0.05$)
	MSTAIQ	2.31	1.85		AS > MSTHIQ ($P < 0.001$)
	TD	.93	1.31		AS > TD ($P < 0.001$)
	AS	4.57	2.21		
	Total	1.95	2.17		
Patterns	MSTHIQ	2.58	1.47	0.69	
	MSTAIQ	2.38	1.31		
	TD	2.24	1.41		
	AS	2.86	1.35		
	Total	2.47	1.39		
Attention to details	MSTHIQ	2.50	1.18	2.21	
	MSTAIQ	2.25	1.00		
	TD	3.00	1.00		
	AS	2.93	1.07		
	Total	2.70	1.09		
Attention switching	MSTHIQ	2.54	1.47	3.22*	AS > MSTHIQ ($P < 0.05$)
	MSTAIQ	2.81	0.66		
	TD	2.83	1.42		
	AS	3.86	1.23		
	Total	2.92	1.35		
Total score	MSTHIQ	12.17	6.04	7.43***	AS > MSTAIQ ($P < 0.05$)
	MSTAIQ	14.50	5.82		AS > MSTHIQ ($P < 0.01$)
	TD	12.93	5.52		AS > TD ($P < 0.01$)
	AS	20.86	6.29		
	Total	14.35	6.52		

MSTHIQ, mathematically and scientifically talented students with high-IQ; MSTAIQ, mathematically and scientifically talented students with average-IQ; TD, typically developing students; AS, students with Asperger's syndrome.
* $P < 0.05$.
*** $P < 0.001$.

5.2. Cognitive profiles and social interaction of the average-IQ MST group

This is the first attempt in the literature to examine these cognitive and social parameters in a MST group with average intelligence. Compared with the high-IQ group, our MSTAIQ students were weaker in PIQ, POI and WMI that may be attributable to the differences in intelligences. Despite similar intelligence to TD students, MSTAIQ students had higher achievement. Concerning social interaction, in contrast to their high-IQ counterparts, the MSTAIQ group did not exhibit less social adjustment problems in social awareness and socialness, suggesting that they may have similar autistic-like social deficits in some social domains. Their scores on these two scales were second highest in the four groups. The authors question whether IQ is a factor that predicts social adjustment, because IQ plays a role in the ability to attend to more events and to handle more different stimulates.

5.3. Cognitive profiles and social interaction of the AS group

In our study, the AS students performed as well as the TD students in similarities, information, picture completion, and object assembly, they even obtained higher mean scores in digit span than the TD students; however, they were significantly weaker in digit symbol-coding and symbol search. Their scores in comprehension, arithmetic, letter-number sequencing, block design, and matrix reasoning were the lowest among the four groups, but significant variations were observed only when compared with the MSTHIQ students. Our finding was similar to that of relevant research investigating cognitive profiles of individuals with AS showing higher VIQ than PIQ (Ghaziuddin & Mountain-Kimchi, 2004; Kaland et al., 2002; Planche and Lemonnier, 2012; Volkmar et al., 2005).

Although the mean score of block design of the AS group was lower than that of the other groups, it was the highest subtest score obtained by the AS group on the performance subscale. A significant variation was determined in comprehension between the AS and MSTAIQ groups ($p < 0.05$) (supplemental Table 2). Comprehension (mean score = 11.71) and arithmetic (mean score = 11.00) had the lowest subtest scores in the verbal task within the AS group. Thus, our results were consistent with previous similar studies (Rumsey & Hamburger, 1988, 1990; Shah & Frith, 1993; Siegel, Minshew, & Goldstein, 1996).

Table 5
Special cases in the MST group.

Group	Mean ± SD AS	No. 206 MSTHIQ	No. 215 MSTHIQ	No. 109 MSTAIQ	No. 118 MSTAIQ	Mean ± SD All participants
Social responsiveness scale	87.86 ± 24.24	**104**	**104**	**96**	**93**	58.77 ± 26.26
Adult autism-spectrum quotient	20.86 ± 6.29	12	**28**	19	**21**	14.35 ± 6.52
Verbal IQ	115.14 ± 17.32	133	144	140	109	121.61 ± 12.59
Performance IQ	102.36 ± 12.58	125	125	117	109	116.64 ± 13.50
Full-scale IQ	110.07 ± 15.79	133	138	126	110	120.90 ± 12.45
Verbal comprehension index	118.07 ± 17.02	133	135	121	**106**	122.02 ± 11.38
Perceptual organization index	108.50 ± 16.04	**109**	132	111	119	117.13 ± 13.57
Working memory index	107.00 ± 21.44	131	155	136	111	115.65 ± 15.49
Processing speed index	90.79 ± 16.29	123	123	125	103	112.76 ± 17.74
Empathetic over-excitabilities	21.71 ± 4.67	**15**	**21**	**18**	25	24.19 ± 4.25
Emotional over-excitabilities	32.57 ± 7.63	32	**39**	30	29	27.02 ± 8.27

MSTHIQ, mathematically and scientifically talented students with high-IQ; MSTAIQ, mathematically and scientifically talented students with average-IQ; TD, typically developing students; AS, students with Asperger's syndrome.
Bold only indicates the score of a particular case is higher than the average score without statistical test.

Predictably, our results provide strong evidence to support that individuals with AS have overt impairment in social awareness, cognition and reciprocity and patterns of restricted, repetitive, and stereotyped behaviors, interests, and activities (Planche and Lemonnier, 2012). In this study, the AS participants demonstrated significantly higher problems on the scales, like hyperactivity/impulsiveness, socio-communication, autism mannerisms, social awareness, socialness, mindreading, and attention switching (Baron-Cohen, 2004; Gau et al., 2013).

Based on the Me Scale II results, we observed that the AS group reported a higher emotional OE than the MSTHIQ group, but a lower empathetic OE. The higher emotional OE refers to higher unstable emotion. On the other hand, the lower empathetic OE refers to lower capacity to recognize emotions of others, which is one of the primary autistic features described in the DSM-IV (Baron-Cohen, 2004).

5.4. Exceptional cases in the MST group

Although the AS group generally demonstrated more deficits in communication and social interactions as assessed by autistic symptom-related scales, such as the SRS and AQ, two MSTHIQ and two MSTAIQ participants, who had been clinically assessed to have no diagnosis of ASD, also scored higher than the average scores of at least one of these two autistic symptom-related scales in the AS group (Table 5). Participant No. 206 reported difficulties in SRS; he received a low score in POI and reported a low empathetic OE. Participant No. 215 reported difficulties in SRS and AQ and reported a low empathetic OE and a high emotional OE. Participant No. 109 reported difficulties in SRS and reported a low empathetic OE and a high emotional OE. Participant No. 118 also reported difficulties in SRS and AQ.

6. Conclusion and suggestions

In this study, various manifestations of cognitive profiles and social interactions across the four groups were observed. The MSTHIQ group displayed a balanced development in cognitive and affective aspects; the MSTAIQ group were weaker in POI and WMI than MSHIQ, and exhibited some adjustment problems in social awareness and socialness; the AS group was weak in PIQ, particularly on the PSI subtests (i.e., digit symbol-coding and symbol search). They demonstrated significantly more severe problems regarding autistic symptoms and also reported a higher emotional OE and a lower empathetic OE. However, four MST students without ASD presented similar difficulties in social reciprocity as autistic-like traits. The findings indicate that educators should assess any social interactions problems among students in the MST class and provide counseling and intervention for students with these social reciprocity problems and help them develop appropriate and adequate social skill to improve their interpersonal relationships. By contrast, AS students reported similar OE traits to our MST students; thus, their talent development needs should be noted and emphasized.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.rasd.2014.04.004.

References

Altman, R. (1983). Social–emotional development of gifted children and adolescents: A research model. *Roeper Review, 6*(2), 65–68.
American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.
Baron-Cohen, S. (2004). Autism: Research into causes and intervention. *Developmental Neurorehabilitation, 7*(2), 73–78.
Baron-Cohen, S. (2002). The extreme male brain theory of autism. *TRENDS in Cognitive Sciences, 6*(6), 248–254.
Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The autism-spectrum quotient (AQ): Evidence from asperger syndrome/high-functioning autism, malesand females, scientists and mathematicians. *Journal of Autism and Developmental Disorders, 31*(1), 5–17.
Baska, L. K. (1989). Characteristics and needs of the gifted. In J. Feldhusen, J. Van Tassel-Baska, & K. Seeley (Eds.), *Excellence in Educating the Gifted* (pp. 15–28). Denver, CO: Love Pub. Co.
Blackburn, A. C., & Erickson, D. B. (1986). Predictable crises of the gifted student. *Journal of Counseling and Development, 64*(9), 552–555.
Buescher, T. M. (1985). A framework for understanding the social and emotional development of gifted and talented adolescents. *Roeper Review, 8*(1), 10–15.
Chang, H.-J. (2001). *A research on the overexcitabilities of gifted and taletend students in Taiwan*. Taipei, Taiwan: National Taiwan Normal University.
Chang, H.-J. (2011). *The study of over-excitabilities: Predicting of learning performance, creativity, psychological adjustment on gifted and regular students*. Taipei, Taiwan: National Taiwan Normal University.
Chang, H.-J., & Kuo, C.-C. (2013). Overexcitabilities: Empirical studies and application. *Learning and Individual Differences, 23*, 53–63.
Chang, Y.-P. (2003). *The emotional development levels and adjustment of math-science taletned students in senior high schools*. Taipei, Taiwan: National Taiwan Normal University.
Chen, Y.-H., & Chen, H.-Y. (2002). *Manual for Wechsler Adult Intelligence Scale III (WAIS-III)*. Taipei, Taiwan: Chinese Behavioral Science Corporation.
Chien, W.-H., Gau, S.S.-F., Chen, C.-H., Tsai, W.-C., Wu, Y.-Y., Chen, P.-H., et al. (2013). Increased gene expression of FOXP1 in patients with autism spectrum disorders. *Molecular Autism, 4*(1), 23.
Chien, W.-H., Gau, S.S.-F., Liao, H.-M., Chiu, Y.-N., Wu, Y.-Y., Huang, Y.-S., et al. (2013). Deep exon resequencing of DLGAP2 as a candidate gene of autism spectrum disorders. *Molecular Autism, 4*(1), 26.
Chou, M.-C., Chou, W.-J., Chiang, H.-L., Wu, Y.-Y., Lee, J.-C., Wong, C.-C., et al. (2012). Sleep problems among Taiwanese children with autism, their siblings and typically developing children. *Research in Autism Spectrum Disorders, 6*(2), 665–672.
Clark, B. (1992). *Growing up gifted: Developing the potential of children at home and at school* (4th ed.). New York: Macmillan.
Constantino, J. N. (2005). *Social Responsiveness Scale (SRS)*. Los Angeles, CA: Western Psychological Services.
Constantino, J. N., Davis, S. A., Todd, R. D., Schindler, M. K., Gross, M. M., Brophy, S. L., et al. (2003). Validation of a brief quantitative measure of autistic traits: Comparison of the social responsiveness scale with the autism diagnostic interview-revised. *Journal of Autism and Developmental Disorders, 33*(4), 427–433.
Constantino, J. N., Hudziak, J. J., & Todd, R. D. (2003). Deficits in reciprocal social behavior in male twins: Evidence for a genetically independent domain of psychopathology. *Journal of the American Academy of Child and Adolescent Psychiatry, 42*(4), 458–467.
Cowen, T. (2009). Autism as academic paradigm. *The Chronicle of Higher Education*, 55.
Cross, T. (1996). Psychological autopsy provides insight into gifted adolescent suicide. *Gifted Child Today Magazine, 19*(3), 22–23 50.
Dabrowski, K. (1938). Typy wzmozonej pobudliwosci psychicznej [Types of increased psychic excitability]. *Biuletyn Instytutu Higieny Psychicznej, 1*(3–4), 3–26.
Dabrowski, K. (1964). *Positive disintegration*. Boston, MA: Little Brown.
Dabrowski, K. (1970). *Mental growth through positive disintegration*. London: Gryf.
Dapretto, M., Davies, M. S., Pfeifer, J. H., Scott, A. A., Sigman, M., Bookheimer, S. Y., et al. (2005). Understanding emotions in others: mirror neuron dysfunction in children with autism spectrum disorders. *Nature neuroscience, 9*(1), 28–30.
Davis, G. A., & Rimm, S. B. (1998). *Education of the gifted and talented* (4th ed.). Boston: Allyn & Bacon.
Ehlers, S., Nydén, A., Gillberg, C., Sandberg, A. D., Dahlgren, S. O., Hjelmquist, E., et al. (1997). Asperger syndrome, autism and attention disorders: A comparative study of the cognitive profiles of 120 children. *Journal of Child Psychology and Psychiatry, 38*(2), 207–217.
Gagné, F. (2000). Understanding the complex choreography of talent development through DMGT-based analysis. *International Handbook of Giftedness and Talent, 2*, 67–79.
Gallagher, S. A. (1985). A comparison of the concept of overexcitabilities with measures of creativity and school achievement in sixth-grade students. *Roeper Review, 8*(2), 115–119.
Gau, S.S.-F., Lee, C.-M., Lai, M.-C., Chiu, Y.-N., Huang, Y.-F., Kao, J.-D., et al. (2011). Psychometric properties of the Chinese version of the Social Communication Questionnaire. *Research in Autism Spectrum Disorders, 5*(2), 809–818.
Gau, S.S.-F., Liu, L.-T., Wu, Y.-Y., Chiu, Y.-N., & Tsai, W.-C. (2013). Psychometric properties of the Chinese version of the social responsiveness scale. *Research in Autism Spectrum Disorders, 7*(2), 349–360.
Ghaziuddin, M., & Mountain-Kimchi, K. (2004). Defining the intellectual profile of Asperger syndrome: Comparison with high-functioning autism. *Journal of Autism and Developmental Disorders, 34*(3), 279–284.
Gilchrist, A., Green, J., Cox, A., Burton, D., Rutter, M., & Le Couteur, A. (2001). Development and current functioning in adolescents with Asperger syndrome: A comparative study. *Journal of Child Psychology and Psychiatry, 42*(02), 227–240.
Gorsuch, R. L. (1983). *Factor analysis*. Hillsdale, NJ: Erlbaum.
Happé, F., & Frith, U. (2010). *Autism and talent* (Vol. 364,). Oxford: Oxford University Press.
Happé, F., & Frith, U. (1996). The neuropsychology of autism. *Brain, 19*, 1377–1400.
Harkness, J. A., & Schoua-Glusberg, A. (1998). Questionnaires in translation. *ZUMA-Nachrichten Spezial, 3*, 87–127.
Huang, P.-H. (2005). *The study of overexcitabilities and creativity of junior high school gifted and talented students*. Taipei, Taiwan: National Taiwan Normal University.
Joseph, R. M., Tager-Flusberg, H., & Lord, C. (2002). Cognitive profiles and social-communicative functioning in children with autism spectrum disorder. *Journal of Child Psychology and Psychiatry, 43*(6), 807–821.
Kaland, N., Møller-Nielsen, A., Callesen, K., Mortensen, E. L., Gottlieb, D., & Smith, L. (2002). A new advanced test of theory of mind: Evidence from children and adolescents with Asperger syndrome. *Journal of Child Psychology and Psychiatry, 43*(4), 517–528.
Koyama, T., Tachimori, H., Osada, H., Takeda, T., & Kurita, H. (2007). Cognitive and symptom profiles in Asperger's syndrome and high-functioning autism. *Psychiatry and Clinical Neurosciences, 61*(1), 99–104.
Kuo, C.-C., Lin, C.-P., Chang, H.-J., Chou, K.-H., Tseng, C.C.-F., Chang, Y.-P., et al. (2012). Sex differences in brain structure between students talented in math and science and their typically developing peers. *Journal of Research in Education Sciences, 57*(2), 25–64.
Larsen, R. J., Diener, E., & Emmons, R. A. (1986). Affect intensity and reactions to daily life events. *Journal of Personality and Social Psychology, 51*(4), 803–814.
Lau, W.Y.-P., Gau, S.S.-F., Chiu, Y.-N., Wu, Y.-Y., Chou, W.-J., Liu, S.-K., et al. (2013). Psychometric properties of the Chinese version of the autism spectrum quotient (AQ). *Research in Developmental Disabilities, 34*(1), 294–305.
Lewis, R. B., Kitano, M. K., & Lynch, E. W. (1992). Psychological intensities in gifted adults. *Roeper Review, 15*(1), 25–31.
Lewis, W. D. (1943). Some characteristics of very superior children. *The Pedagogical Seminary and Journal of Genetic Psychology, 62*(2), 301–309.

Lin, M.-H. (2003). *Overexcitabilities and peer relationships of gifted students*. Taipei, Taiwan: National Taiwan Normal University.
Liu, M.-J. (2008). Screening adults for asperger syndrome and high-functioning autism by usig the autism-spectrum quotient (AQ). *Bulletin of Special Education, 33*(1), 73–92.
Lord, C., Rutter, M., & Le Couteur, A. (1994). Autism diagnostic interview-revised: A revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of Autism and Developmental Disorders, 24*(5), 659–685.
Lovecky, D. (1993). The quest for meaning: Counseling issues with gifted children and adolescents. In L. K. Silverman (Ed.), *Counseling the Gifted and Talented* (pp. 29–50). Denver, CO: Love Publishing Co.
Lovecky, D. V. (1992). Exploring social and emotional aspects of giftedness in children. *Roeper Review, 15*(1), 18–25.
McLeod, L. D., Swygert, K. A., & Thissen, D. (2001). Factor analysis for items scored in two categories. In D. T. H. Wainer (Ed.), *Test Scoring* (pp. 189–216). Mahwah, NJ: Lawrence Erlbaum Associates.
Mendaglio, S. (1998). Understanding gifted children's intense emotionality: Sensitivity. *Annual conference of the society for the advancement of gifted education* (pp. 17–20). Alberta, Canada: Calgary University.
Miller, N. B., Silvermany, L. K., & Falk, R. F. (1995). Emotional development, intellectual ability, and gender. *Journal for the Education of the Gifted, 18*(1), 20–38.
Mottron, L. (2004). Matching strategies in cognitive research with individuals with high-functioning autism: Current practices, instrument biases, and recommendations. *Journal of Autism and Developmental Disorders, 34*(1), 19–27.
Noterdaeme, M., Wriedt, E., & Höhne, C. (2010). Asperger's syndrome and high-functioning autism: Language, motor and cognitive profiles. *European Child and Adolescent Psychiatry, 19*(6), 475–481.
Ozonoff, S., Rogers, S. J., & Pennington, B. F. (1991). Asperger's syndrome: Evidence of an empirical distinction from high-functioning autism. *Journal of Child Psychology and Psychiatry, 32*(7), 1107–1122.
Ozonoff, S., South, M., & Miller, J. N. (2000). DSM-IV-defined Asperger syndrome: Cognitive, behavioral and early history differentiation from high-functioning autism. *Autism, 4*(1), 29–46.
Parker, W. D. (1997). An empirical typology of perfectionism in academically talented children. *American Educational Research Journal, 34*(3), 545–562.
Peelen, M. V., & Downing, P. E. (2007). The sight of others' pain modulates motor processing in human cingulate cortex. *Cerebral Cortex, 17*(9), 2214–2222.
Piirto, J. (1994). *Talented children and adults: Their development and education*. New York: Macmillan/Merrill.
Planche, P., & Lemonnier, E. (2012). Children with high-functioning autism and Asperger's syndrome: Can we differentiate their cognitive profiles? *Research in Autism Spectrum Disorders, 6*(2), 939–948.
Robinson, N. M., & Noble, K. D. (1991). Social–emotional development and adjustment of gifted children. In M. C. Wang, M. C. Reynolds, & H. J. Walberg (Eds.), *Handbook of special education: Research and practice* (pp. 57–76). New York: Pergamon Press.
Roedell, W. C. (1984). Vulnerabilities of highly gifted children. *Roeper Review, 6*(3), 127–130.
Roeper, A. (1982). How the gifted cope with their emotions. *Roeper Review, 5*(2), 21–24.
Rumsey, J. M., & Hamburger, S. D. (1988). Neuropsychological findings in high-functioning men with infantile autism, residual state. *Journal of Clinical and Experimental Neuropsychology, 10*(2), 201–221.
Rumsey, J. M., & Hamburger, S. D. (1990). Neuropsychological divergence of high-level autism and severe dyslexia. *Journal of Autism and Developmental Disorders, 20*(2), 155–168.
Saulnier, C. A., & Klin, A. (2007). Brief report: Social and communication abilities and disabilities in higher functioning individuals with autism and Asperger syndrome. *Journal of Autism and Developmental Disorders, 37*(4), 788–793.
Shah, A., & Frith, U. (1993). Why do autistic individuals show superior performance on the block design task? *Journal of Child Psychology and Psychiatry, 34*(8), 1351–1364.
Siegel, D. J., Minshew, N. J., & Goldstein, G. (1996). Wechsler IQ profiles in diagnosis of high-functioning autism. *Journal of Autism and Developmental Disorders, 26*(4), 389–406.
Silverman, L. K. (1983). Isssues in affective development of the gifted. In J. Van Tassel-Baska (Ed.), *A practical guide for counseling the gifted* (pp. 6–21). Reston, VA: Council for Exceptional Children Press.
Silverman, L. K. (1990). Social and emotional education of the gifted: The discoveries of Leta Hollingworth. *Roeper Review, 12*(3), 171–178.
Silverman, L. K. (1993). A developmental model for counseling the gifted. In L. K. Silverman (Ed.), *Counseling the gifted and talented* (pp. 51–78). Denver, CO: Love Publishing Co.
Szatmari, P., Bartolucci, G., & Bremner, R. (1989). Asperger's syndrome and autism: Comparison of early history and outcome. *Developmental Medicine and Child Neurology, 31*(6), 709–720.
Tsai, L.-W. (2006). *A study on influential factors of life adjustment of elementary gifted students*. Taipei, Taiwan: Taipei Municipal University of Education.
Volkmar, F. R., Paul, R., Klin, A., & Cohen, D. J. (2005). *Handbook of autism and pervasive developmental disorders, diagnosis, development, neurobiology and behavior* (Vol. 1,). Hoboken, NJ: John Wiley & Sons.
Vuilleumier, P., & Pourtois, G. (2007). Distributed and interactive brain mechanisms during emotion face perception: Evidence from functional neuroimaging. *Neuropsychologia, 45*(1), 174–194.
Whitmore, J. R. (1980). *Giftedness, conflict and underachievement*. Boston: Allyn and Bacon.
Xie, Y. C. (2005). *The study of overexcitabilities and social emotional adjustment of musically talented junior high school students*. Taipei, Taiwan: National Taiwan Normal University.