Gender Differences in Gifted Children's Spatial, Verbal, and Quantitative Reasoning Abilities in Taiwan

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Previous findings have indicated that the reasoning abilities of gifted students are associated with gender differences. However, the factors affecting the emergence of gender differences, including age, remain to be studied. The main purpose of this study is to investigate whether the spatial, verbal and quantitative reasoning abilities of gifted children exhibit gender differences prior to entering elementary school. A sample of 32 young children identified as academically gifted were administered individual intelligence tests in order to find out their verbal and spatial IQ scores, as well as their arithmetic scores. The mean performance of these male and female young gifted children on three reasoning measures showed that gender differences were not significantly different. Means across sub-skills however, revealed that boys scored higher than girls on tasks in which assembly and number series abilities were required.

1. INTRODUCTION

It is generally believed that visual-spatial ability and mathematical ability are highly correlated (Robinson, Abbott, Berninger, & Busse, 1996), and the latter plays a critical role in academic and career selections, especially those associated with science and technology. Several lines of evidence show that biologically, males have better spatial-mathematical reasoning ability than females, whereas females have better verbal reasoning ability than males. For example, in view of recent findings in neuroscientific research, Moir and Jessel (1993) concluded that interactions between hormones, produced at embryonic and adolescent stages, and the cerebrum influence human spatial-mathematical ability, in such a way that female hormones exhibit inhibitory effects while male hormones exhibit enhanced effects. Furthermore, the areas of math and science are traditionally not pursued by women and are often viewed as unfeminine (Armstrong, 1985; Benbow, 1988; Casserly & Rock, 1985; Eccles et al., 1985; Fox, Brody, & Tobin, 1985; Mills, 1992; Subotnik, Duschl, & Selmon, 1991). Parents and teachers tend to have lower expectations towards the math and science achievements of girls. These barriers and stereotypes significantly restrict the development of females' spatial-mathematical ability (Callahan, 1991; Greenber, 1990; Kerr, 1991; Linn & Hyde, 1989).

Among the great debates on the gender issue, one of the most consistent findings is that from high school on men generally outperform women in spatial-mathematical ability (e.g., Benbow, 1988; Hedges & Nowell, 1995; Hyde, Fennema, & Lamon, 1990; Weiner & Robinson, 1986). Moreover, such gender difference is mainly manifested in, and the most pronounced as far as mathematically gifted young adolescents are concerned (Robinson et al., 1996). One of the most notable studies since 1972 is the 'Study of Precocious Youth' by a Johns Hopkins group. Over a time period of 20 years, and based on large samples, this group finally concluded that, in adolescence, males dominate the highest ranges of mathematical ability, and the gender differences cannot be attributed to test bias (Benbow, 1992, pp. 99-100; Benbow & Stanley, 1980; 1983; Stanley, 1989).

However, when do these gender differences of gifted students start? There were only very few investigators who discovered precocious abilities in the very young. Having studied academically gifted students from their second to sixth grades, Mills, Ablard, and Stumpf (1993) found that males outperform females in terms of mathematical concepts, numerical relationships and algorithmic applications. Stillman

(1982) found that gifted males from 5.5 to 7.3 years old out-perform their female counterparts having identical IQs, when it comes to spatial reasoning ability. In addition, mathematically gifted male students, 5.5 to 6.5 years of age, outperform their female counterparts in quantitative ability and spatial working memory span; however, there appears to be no gender difference regarding the performance in verbal ability (Robinson et al., 1996). Hence, the complexity of cognitive gender differences in the very young talented population remains unexplained, including the appearance and direction of these differences.

Robinson et al. (1997) proposed that mathematically and visual-spatially gifted young girls needed additional support and encouragement. Nevertheless, without the understanding of the nature, the causes, and the effects of these gender-related differences in cognitive functioning, it becomes more difficult to provide appropriate accommodations for the growth of cognitive skills in girls and boys with particular talents. Thus, this issue awaits further investigation. Because the earliest emergence of the gender differences currently remains unclear, the aim of this study is to examine whether Taiwanese gifted boys and girls perform statistically differently with respect to their spatial, verbal and quantitative reasoning abilities prior to receiving formal schooling. These research results may not only potentially echo or confirm previous findings by others in the U.S.A, they may also provide suggestions regarding early identification and intervention of Taiwanese gifted children prior to becoming susceptible to the social and genetics parameters.

2. METHODS

2.1 Participants

Taiwanese children enter elementary school at age 6. However, there are regulations that allow for early entrance to elementary school for gifted kindergarteners in approximately half of the municipalities and counties in Taiwan. Therefore, generally speaking, kindergarten age is the earliest age at which intellectually gifted children come to the attention of the state in Taiwan.

Taoyuan County, a suburban area near Taipei city, is one of the counties in Taiwan that recognize the need of young gifted children for an early admission to first grade. In this study, the population targeted approximately 80 children accepted for early entrance from among 1000 applicants or so, in May 2002 in Taoyuan County. Prior to entering elementary school, 32 early entrants participated in the current study.

These young volunteer participants were made up of 20 boys and 12 girls coming from middle to upper-middle socio-economic status families.

In Taoyuan County, in order to qualify for early admission to first grade, children must meet the pre-defined eligibility criteria: possess an IQ of two or more standard deviations above the mean on a standardized intelligence test, and demonstrating mature social-emotional development based on parent and teacher questionnaires, plus observation of the child, by professional psychologists, as it engages in small group activities. All the identification processes are formal and are carried out by the department of education of Taoyuan County.

2.2 Procedures

After passing the screening for early admission to first grade, the parents of the eligible children were encouraged to contact the researcher, who is a consultant for gifted children in Taoyuan County, to provide them with a better understanding of what early entrance to elementary school means, as well as explain to them the special needs of a gifted child. Afterwards, parents and their gifted children were invited to participate in this study as well as other symposia on education for the gifted.

All participants in this study were tested individually at a center for special education, department of special education, Chung Yuan Christian University, using the Wechsler Pre-school and Primary Scale of Intelligence-Revised, Taiwanese Version (WPPSI-R) (2000), the Cognition-Symbol-System (CSS) subtest of the Structure of Intellect Learning Abilities-Form L, Taiwanese Version (SOI, Form L, 1996), and the Test of Non-verbal Intelligence, Taiwanese Version (TONI) (1996). Testing sessions were conducted during late June and early July 2002. The mean age of the 32 participants was 5.66 years (SD = .15) at the time of testing in this study.

2.3 Material Instruments

Comprehensive measures of intellectual ability, suitable for administration to young gifted Taiwanese children are very limited. The most well-constructed and widely used measures for young children are SOI Test-Form L, Easy-and-Quick Intelligence Scale for Children (EQISC), TONI, and WPPSI-R (In Taiwan we don’t have WPPSI-III and Stanford–Binet Intelligence Scale). For a sample of 30 Taiwanese gifted kindergarteners, the TONI IQ correlated significantly with the WPPSI-R Verbal IQ, WPPSI-R Performance IQ, and the WPPSI-R Full Scale IQ ($r = +.39$, $r = +.58$, $r = +.58$ respectively; $p < .05$) (Fan, 2001). Additionally, the EQISC Full Scale IQ correlated significantly with the WPPSI-R Verbal IQ, WPPSI-R Performance IQ, and the WPPSI-R Full Scale IQ concerning the sample of 30 gifted children ($r = +.41$, $r = +.75$, $r = +.63$, respectively; $p < .05$). Therefore, acceptable concurrent validities of WPPSI-R and TONI with young gifted children were suggested according to their relationships to general intelligence test performances (Fan, 2001).

The Test of Non-verbal Intelligence (TONI) was developed by Brown, Sherbenou, and Johnsen (1982). The TONI-2 was revised in 1990, and, based on this revised version, the Taiwanese TONI was revised in 1996 and published by Psychology Press in Taipei. The TONI (1996) is a nationally standardized test for use with children 4-18 years of age. Construct validity and acceptable reliability (the internal consistency coefficient = .856) are reported in the Taiwanese TONI manual. From simple through difficult graphic stimuli, TONI is purported to measure abstract reasoning and visual-spatial problem solving.

The WPPSI-R (2000) is used to assess cognitive abilities of young children ages 3 to 7.25 years of age. The Verbal scale, contained in the WPPSI-R includes subtests for Information, Comprehension, Arithmetic, Vocabulary, and Similarities. The WPPSI-R Performance scale includes Object Assembly, Geometric Design, Block Design, Matrix Reasoning, and Picture Completion subtests. Note that ‘Mazes’ from the American WPPSI-R Performance Scale was deleted and a new Performance subtest called ‘Matrix Reasoning’ was substituted in the Taiwanese WPPSI-R. Although generally speaking, the Taiwanese WPPSI-R followed the basic structure and contents of the American WPPSI-R, there were some modifications as well as some new items added, based on cultural and social differences; surely, we renormed the WPPSI-R. The data in the Taiwanese WPPSI-R manual reveals that the split-half reliabilities of Verbal, Performance, and Full Scale are .94, .89, and .95, respectively, and that the test-retest reliabilities for the Verbal, Performance, and Full Scale are also adequate (.88, .89, .91, respectively). When carefully applied to young children, one can understand the nonverbal reasoning, spatial ability and perceptual organization of children by means of the Performance scale scores and the Performance IQ (PIQ) , as well as understand their verbal reasoning and skills via Verbal scores and Verbal IQ (VIQ). In this study, WPPSI-R PIQ and TONI IQ were used as indicators of visual-spatial reasoning ability, while the WPPSI-R VIQ was used as an indicator of verbal reasoning.

Due to limited availability of early mathematics ability and achievement tests, only two measures of quantitative reasoning are included in the current study, i.e., the cognition-symbol-system (CSS) subtest of the Structure of Intellect Learning Abilities-Form L (Taiwanese SOI-Form L; Chen, 1996) and the Arithmetic subtest of the revised Wechsler Preschool and Primary Scale of Intelligence (Taiwanese WPPSI-R; Chen & Chen, 2000).

The Taiwanese SOI-Form L, similar to TONI and WPPSI-R, is a nationally- normed standardized instrument used for children in Grades K-3. The CSS subtest consists of 10 questions on number series that tap the knowledge and comprehension of numeric relationships. According to the Taiwanese manual, the CSS subtest is correlated with math achievement (.48, $p < .001$, $N = 578$) with a test-retest reliability that is adequate (.80). Besides the CSS subtest, the Arithmetic subtest of the WPPSI-R Verbal scale was used to assess the subjects' quantitative knowledge, concept, and calculation.

3. RESULTS

The purpose of this study was to investigate if the verbal, spatial, and quantitative reasoning abilities of young gifted Taiwanese children exhibit gender differences. Score differences for gender were examined for statistical significance with t-tests. Examination of the means for the two genders regarding WPPSI-R VIQ showed that Verbal IQs for boys ($M = 119.15$, $SD = 10.65$) versus girls ($M = 116.17$, $SD = 12.90$) were not significantly different ($t = .71$, $p > .05$). Likewise, there were no significant differences between boys' mean scores and girls' mean scores across any of the verbal subtests in WPPSI-R (see Table 1).

The mean TONI IQs for boys was 139.15 ($SD = 2.92$) and for the girls it was 139.50 ($SD = 1.73$). The significance test showed no gender differences in performance on the TONI ($t = -.38$, $p > .05$). After further exploring the subjects' spatial reasoning as assessed by the WPPSI-R Performance scale, the score differences according to gender were not significant in any of the following tests; including Geometric Design, Block Design, Matrix Reasoning, and Picture Completion subtests (see Table 1). On the Object Assembly subtest however, boys scored higher overall than the girls ($t = 2.22$, $p < .05$). In addition, on 4 of the 5 subtests of the Performance scale, boys scored higher than girls (ranging from substantial to slight).

Regarding quantitative measures, the girls' score ($M = 14.25$, $SD = 1.48$) was slightly higher than that of the boys (M = 14.00, SD = 2.08) based on the Arithmetic subtest scores, but the score difference was not significant (see Table 1). On the other hand, the CSS subtest scores of boys (M = 6.75, SD = 2.12) was significantly higher than those of girls (M = 4.92, SD = 1.73) ($t = 2.52$, $p < .05$), revealing gender differences in favor of boys in number series ability.

The tests for homogeneity of variance (Levene's test) and for normality (Shapiro-Wilk) were conducted for all scores. The results of these tests indicated that the TONI IQ and CSS scores did not satisfy the assumption of normality ($ps < .01$) and the TONI IQ did not satisfy the assumption of homogeneity of variance (Levene (1,30) = 6.009, $p = .020$). Thus, the Mann-Whitney U tests were employed to analyze the data again. The results were similar to those for the t-tests, revealing that young boys only had statistically higher mean scores of object assembly and CSS compared to the girls ($U = 71.00$, $p = .054$, and $U = 50.50$, $p = .006$, respectively).

4. DISCUSSION

This is the first study to investigate precocious abilities at so early an age in Taiwan. In the select and small sample of the present study, the significance tests show no gender differences in general reasoning abilities in the group of both academically and socially precocious children around the age of 5.6 years. Overall, both male and female early entrants are similarly advanced in verbal, visual-spatial, and arithmetic abilities before entering elementary school. When compared with studies conducted by Robinson et al. (1996) on math-precocious young children and by Stillman (1982) on gifted children, aged 5.5 to 7 years in the U.S., the verbal reasoning abilities of the young children in this study do not appear to have any gender differences, which is in agreement with the U.S. studies. Among the quantitative reasoning findings in this study, only the result of the number series confirms previous studies; young males tend to score higher than females on number relationships/series, but score equally on number knowledge and concept in this study. Accordingly, it may be that number relationships need more attention in the math reasoning development of gifted girls. The direction of such a difference needs further research.

In addition, it is important to understand the gender differences in the performance in subcategories of a measure (Mills et al., 1993). Across the subtests of WPPSI-R Verbal, gender differences are not statistically significant at $p < .05$. Across WPPSI-R Performance subtests, the results of the tests indicate that gender differences emerge only in Object Assembly. Some studies have shown that pre-school boys, compared with pre-school girls, are much more interested in building blocks, assembling machinery, and working puzzles (e.g., Eisenberg, Murray, & Hite, 1982; Lever, 1976, 1978; Moir & Jessel, 1993). If this is also true for the gifted, then the main reason of the gender difference in young children's assembly ability may stem from their differences in experiences and interests. Further investigation should be conducted to determine if the preferences of young gifted boys and girls for choice of games and play affect their visual-spatial ability performance.

Table 1 Comparison of Scores on WPPSI-R Subtests by Sex

Subtest	Sex	Mean	SD	t	p
Information	Boys	13.45	2.24	0.58	0.57
	Girls	12.92	2.97		
Comprehension	Boys	12.40	3.32	0.25	0.80
	Girls	12.08	3.68		
Arithmetic	Boys	14.00	2.08	- 0.36	0.72
	Girls	14.25	1.48		
Vocabulary	Boys	12.80	3.11	1.11	0.28
	Girls	11.58	2.84		
Similarities	Boys	12.45	2.26	0.67	0.51
	Girls	11.92	2.02		
Object Assembly	Boys	12.70	3.10	2.22	0.03*
	Girls	10.33	2.61		
Geometric Design	Boys	13.70	2.70	- 0.56	0.58
	Girls	14.25	2.70		
Block Design	Boys	14.55	2.76	1.57	0.13
	Girls	12.92	3.00		
Matrix Reasoning	Boys	15.00	1.45	1.07	0.29
	Girls	14.42	1.56		
Picture Completion	Boys	12.70	2.11	1.10	0.28
	Girls	11.92	1.62		

*p<.05

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