Testing Lynn's Theory of Sex Differences in Intelligence in a Large Sample of Nigerian School-Aged Children and Adolescents (*N* >11,000) using Raven's Standard Progressive Matrices Plus

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Sex differences in intelligence have been much disputed for many decades. The present study examined the issues of whether sex differences in intelligence change during development. In total, 11,164 children (mean age = 13.5 years; *SD* = 2.6 years) completed the Standard Progressive Matrices Plus (SPM+). From age 8 to 19 years, sex differences in the total score of the SPM+ increased from -0.06*d* (favoring females) to 0.46*d* (favoring males), with an average of 0.23*d*. Our findings support Lynn's developmental theory of sex differences in cognitive abilities.
Key Words: Nigeria, SPM+, Intelligence, Sex differences, Cognitive ability.

For approximately a century sex differences in intelligence have been controversial among psychologists and the general public. The controversy was originally kindled by Terman (1916) and Spearman (1923), who asserted that there is no sex difference in general intelligence. Later research findings on this issue were largely inconsistent, however. Some researchers reported a male advantage (e.g. Irwing, 2012; Irwing & Lynn, 2005; Jackson & Rushton, 2006; Lynn & Irwing, 2004; Nyborg, 2005), whereas others showed no differences between the sexes (e.g. Colom et al., 2002; Deary et al., 2007), and still others found a female advantage (e.g. Jensen, 1998; Keith et al., 2008; Reynolds et al., 2008; see also Halpern, 2012, for a recent review of the literature). These inconsistencies may partly be due to the variability in cognitive ability tests, analytic methodologies (e.g., using a latent variable approach vs. an observed test score approach), and diversity of samples, in particular with regard to age.

Halpern (2012) gives a detailed review of the various theories trying to explain sex differences in intelligence. She describes biological hypotheses that focus on genes, hormones, brains, evolutionary pressures, and brain-behavior relationships. She also describes psychosocial hypotheses that focus on sex-role stereotypes and a large number of other psychosocial hypotheses. Surprisingly, of the large number of papers testing Lynn's developmental theory of sex differences only one is mentioned in passing. In the present paper, however, we focus on Lynn's theory using data collected from Nigeria.

Lynn (1994, 1999) argued that sex differences in cognitive abilities were due to sex differences in maturational rates. According to Lynn's developmental theory, girls mature earlier than boys both physically and mentally prior to puberty, but from the age of approximately 15 years onwards the growth of girls decelerates while that of boys continues. For this reason, girls outperform boys up to the age of about 14 years but males begin to outperform females around puberty and this male advantage continues through adulthood. To date, however, there is no consensus on the age at which sex differences emerge. For example, Lynn and Irwing (2004) showed in a meta-analysis of 54 studies of sex differences on the Standard Progressive Matrices (SPM) that the advantage of boys emerges at the age of 15, increases in late adolescence, and remains stable for the whole age range of 20–29 through 80–89 years. However, Liu and Lynn (2011) observed a consistent male advantage in the Full Scale IQ scores at ages as young as 5 to 6 years in a Chinese sample, and on spatial ability tests of the Wechsler Preschool and Primary Scale of Intelligence (WPPSI) among children aged four and five years in China, Japan, and US. The magnitudes of sex differences were inconsistent as well. While Lynn and Irwing's meta-analysis demonstrated an average sex difference of 0.33*d*, two large-scale studies (Lynn & Kanazawa, 2011; Rojahn & Naglieri, 2006) converged to indicate that although sex differences followed the developmental pattern as Lynn (1994, 1999) suggested, the differences after puberty were less than 0.12*d* and thus concluded that the differences were practically insignificant.

While sex differences in cognitive abilities have been extensively studied in Europeans, Americans, and Asians, there are only a few reports on sex differences in cognitive abilities among Africans. Lynn (2002) administered the Raven's SPM to 3,979 15- to 16-year-olds in secondary schools in South Africa and found that males obtained a higher mean equivalent to 0.16*d* among 15-year-olds and to 0.31*d* among 16-year-olds, suggesting that the sex difference increases with age. However, these differences were not consistent across ethnic groups in the study sample. More recently, Bakhiet et al. (2015) analyzed scores of the SPM in 7226 students aged from 6 to 18 years in Sudan. Females tended to perform slightly better than males on the total score up to age 11 years, with a highest *d* of -.12. From the age of 12 years onwards, however, a male advantage began to appear even though the magnitudes of sex differences were generally moderate ranging from *d* = .10 to *d* = .20 with an exception of *d* = .66 for 17-year-olds.

Jensen (1998, ch. 13) gives an excellent review of sex differences in specific tests and in first-order factors. Males excel in spatial-visualization tests, and especially on tests in which spatial ability is combined with types of specific knowledge content with which males are typically more familiar, such as information about electronics. Males also have a small advantage in math ability. Women have an advantage on tests of verbal fluency, and on scholastic-type achievement tests involving verbal content such as reading, writing, grammar, and spelling. Moreover, women have an advantage on tests of perceptual speed, short-term memory, and speed and accuracy. However, a fundamental question is whether there are sex differences on the *g* factor. The use of Raven's SPM would allow a strong test of sex differences in the *g* factor, because the Raven's SPM is a test of reasoning ability known to be one of the best measures of general intelligence (Jensen, 1998; Mackintosh, 1996).

In view of the findings to date, it is evident that more data are needed to resolve the issue of sex differences in intelligence. Using the Standard Progressive Matrices Plus (SPM+; Raven, 2008), the present study addresses the question of whether the developmental theory of sex differences in intelligence can be confirmed among Nigerians.

Method

1. Sample and Procedure

The present study consisted of 11,164 students (mean age = 13.5, *SD* = 2.6 years) drawn from three separate samples in the Nigerian twin-and-sibling studies

(Hur et al., 2013). Students who skipped the question on sex (*N* = 124) or younger than eight years (*N* = 75) or older than 19 years (*N* = 119) were not included in data analysis. There were approximately equal numbers of males and females aged between 8 and 19 years. The first sample consisted of twins and siblings collected from 45 public junior and senior secondary schools covering all six administrative areas in Abuja Federal Capital Territory (FCT). Note that as twins and siblings share segregating genes and rearing-family environment, only one member of each twin or sibling pair was used for data analysis (*N* = 905). This procedure enables all of the subjects in the study sample to be independent from each other, avoiding violation of the assumption of independent data points. Mean age of this sample was 14.9 years (standard deviation SD 2.0 years). The 45 schools were chosen for their large size of enrollment (typically *N* > 500) as more twins were available in larger schools.

The second sample comprised 8979 students collected from 17 public primary and 13 public junior and senior secondary schools across all six school districts in Lagos State. The 30 schools were selected to obtain a sample maximally representative of the students attending public schools covering very rural to very urban areas in Lagos State. In primary schools, only students higher than grade three were allowed to participate in the study. The average age of these students was 13.1 (SD = 2.6) years. A detailed description of this sample can be found in Hur (2016).

The third sample was composed of 1280 individual twins from 212 public junior and senior secondary schools across six school districts in Lagos State. Again, only one member of each pair was selected. The mean age of these twins was 14.5 (*SD* = 1.9) years. Data collection procedures were very similar in all three samples except that when we tested twins, there were smaller numbers of subjects in the testing room. Staff members in the Ministry of Education and Education Boards were consulted when we chose schools in each district. Bringing letters of approval from the Education Boards and the Ministry of Education, the first author visited schools and gave tests to twins and sibling pairs in a library or classroom in the school. Research assistants and teachers were available in the testing room to give instructions and monitor the tests. We encouraged students to try all items of the SPM+, asking them to make their best guess when they felt items were very difficult. We did not limit the testing time.

2. Measure

The SPM+ consists of 60 matrix items divided into five sets (A, B, C, D, & E) constructed to become progressively more difficult moving from set A to E. Validity and reliabilities of the SPM+ have been well established (Raven, 2008). As the

SPM+ is a non-verbal test, it has commonly been used to assess sex differences in cognitive abilities in diverse populations with different languages and cultural backgrounds.

3. Data Analysis

Three steps were taken in data analysis. First, we computed means and *SD*s by sex and by age. Second, we performed ANOVA and tested the main effects of sex and age, and their interaction for the total score of the SPM+. Statistically significant sex by age interaction would serve as evidence for the developmental change in sex differences in cognitive abilities, indicating that sex differences in the main effects vary across the age groups. Finally, to determine the magnitudes of sex differences on the total score of the SPM+, we computed the standardized effect size of difference (*d*) on SPM+ between males and females for each age group. As *d* was calculated as males' mean minus females' mean divided by a pooled estimate of the standard deviation, a positive value indicated a higher score in males and a negative value, a higher score in females.

2. Results

Table 1 shows means and *SD*s for the total score of the SPM+ by age and sex, and Figure 1 presents a graphic representation of the magnitudes of sex differences (*d*) by age. ANOVAs for the total score of the SPM+ produced significant main effects for age, $F = 127.06$, $p<.001$, and sex, $F = 76.09$, $p<.001$. Except for the youngest group, ages 8 to 9 years, males were consistently higher than females in the total SPM+ score. These sex differences attained statistical significance at $p < .001$ at every age except 8 to 9 years and 11 years. With increasing age, both sexes showed gradual increases in their mean scores on SPM+ peaking at ages around 15 years for girls and around 16 years for boys. The effect of age x sex interaction was also significant for the total score of the SPM+, $F = 4.25$, $p<.001$, indicating that the magnitude of sex differences becomes significantly larger with increasing age (Figure 1). In support of Lynn's developmental theory, a notable increase in sex differences began to occur at around age 16 years. The estimates of *d* started from -.06 at ages 8-9 years, reached .34 at age 16 years and then increased quite sharply to .46 at ages 18-19 years, with an average of .23 across the whole age range.

Table 1. *Mean ± standard deviation (SD) for the total score of the SPM+ for males and females by age, and standardized sex difference d.*

	Male		Female		
Age (years)	*N*	Mean ± *SD*	*N*	Mean ± *SD*	*d*
8-9	457	14.5 ± 5.7	454	14.9 ± 6.7	-0.06
10	319	18.0 ± 7.8	390	16.4 ± 7.1	0.21***
11	586	18.9 ± 8.3	568	18.1 ± 8.1	0.10
12	664	20.7 ± 8.6	638	19.2 ± 8.2	0.18***
13	846	22.0 ± 9.0	820	20.1 ± 8.3	0.22***
14	763	23.4 ± 9.1	716	21.2 ± 8.9	0.24***
15	603	24.9 (9.2)	632	23.0 (9.1)	0.21***
16	577	25.8 (9.2)	567	22.7 (8.9)	0.34***
17	441	25.3 (8.7)	439	22.2 (8.4)	0.36***
18-19	327	25.0 (8.7)	357	21.2 (8.0)	0.46***
Average		22.0 (9.2)		20.1 (8.6)	0.23

Note. *** Sex difference significant at $p < .001$.

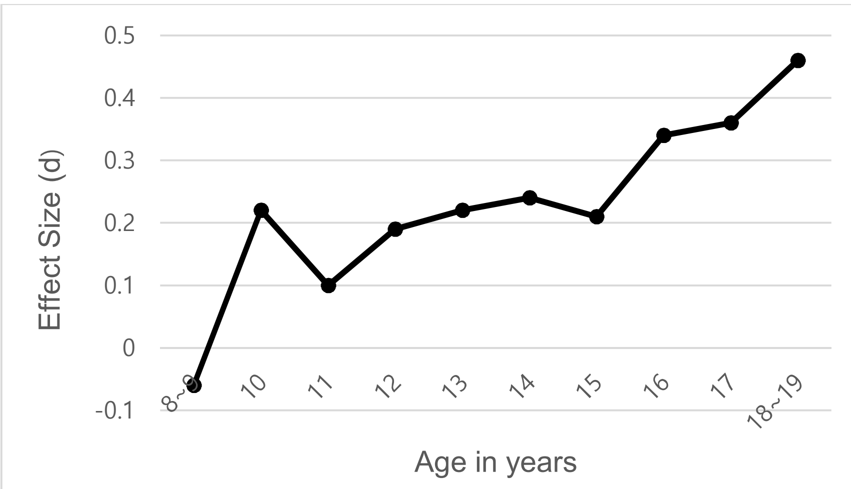

Figure 1. *Standardized effect size (d) of sex differences in the total score of the SPM+ from age 8 to 19 years.*

Discussion

The present study partially confirms the developmental theory of sex differences in cognitive abilities among African children and adolescents in Nigeria. From ages 8 to 19 years, sex differences in the total score of the SPM+ increased steadily from -.06*d* to .46*d*, with an average of .23*d*. A sharp sex difference emerged at age 16 when most children passed puberty. These results are consistent with the findings from the meta-analysis by Lynn and Irwing (2004) in that a large sex difference emerges at the end of puberty. However, unlike other studies, we show that boys perform better than girls at almost all ages although the magnitudes of the sex differences before age 16 were much smaller than those found from age 16 onward.

In support of sex differences in cognitive abilities, Kimura and Hampson (1994) suggested that sex hormones such as testosterone and estradiol influence sex differences in cognitive abilities, especially in spatial rotation. More recently, many neuroimaging studies yielded evidence for sex differences in structural and functional characteristics of the brain. For example, Gur et al. (1999) and Haier et al. (2005) showed that global white matter volume correlated more strongly with intelligence in adult women, while global gray matter volume correlated more strongly in adult men. In support of these results, Schmithorst (2009) found in a longitudinal study based on children aged from 5 to 18 years that girls developed a positive correlation of fractional anisotropy (FA; a marker for white matter organization) with IQ with increasing age in frontal and fronto-parietal regions in white matter, while boys developed a negative correlation of FA in these regions. In another developmental study Wang et al. (2012) found that adolescent boys (13-18 years) continued to demonstrate white matter maturation, whereas girls reached the mature state earlier. Taken together, these studies suggest that sex differences in intelligence may be due to different developmental trajectories of brain structures between the sexes.

Limitations

The use of student samples for studies of sex differences in cognitive abilities has been criticized because students are not necessarily representative of the general population (Dykiert, Gale & Deary, 2009; Flynn & Rossi-Casé, 2011). Although the present sample was recruited from many public schools across all administrative areas in Lagos State and Abuja, FCT in Nigeria, adolescents not enrolled in schools or students in private schools were not included in the present sample, indicating that children and adolescents at both high and low ends of the cognitive ability distribution among Africans in Nigeria are likely to be under-represented in the present sample. Still, the very large size of the sample and the careful sampling allow us to conclude that our sample is highly representative of the public schools in a specific part of Nigeria.

Suggestions for Future Research

Our finding of gender differences in cognitive abilities in Nigeria renders support for Lynn's developmental theory of sex differences. Although our sample is a large one, this study is the only one in Nigeria conducted as far as we understand. More studies need to be carried out so that a meta-analysis can be performed (Schmidt, 1992), which will allow us to make strong conclusions and examine whether sex differences in cognitive abilities are moderated by ethnic or racial groups. The World Economic Forum (2011) determined that in Nigeria, gender gaps in education, economic empowerment and political participation remain. Moreover, cultural and religious influences foster the maintenance of a 'son preference' within the country, which may also influences teachers' attitudes and behaviors towards boys versus girls. These influences should also be taken into account in future studies.

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