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Gender differences in cognitive development

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Introduction

Gender differences in cognitive abilities have been widely analyzed in the psychological and neuropsychological literature (e.g., Hyde, 1981; Buffery & Gray, 1972; Caplan, Crawford, Hyde, & Richardson, 1997; Deary, Thorpe, Wilson, Starr, Whalley, 2003; Halpern, 1992; Fairweather, 1976; Hedges & Nowell, 1995; Kimura, 1999; Maccoby & Jacklin, 1974; Stumpf, & Jackson, 1994; Weiss et al., 2003). Three major differences in cognitive abilities between men and women have usually been reported: (1) higher verbal abilities, favoring women; (2) higher spatial abilities, favoring men; and, (3) higher arithmetical abilities, also favoring men. However, differences in calculation abilities have at times been interpreted as a result of men's superior spatial abilities (Benbow, 1988; Geary, 1996), hence, these three differences could be reduced to just two.

It has frequently been stated that women attain a higher performance in a variety of verbal tests (e.g., Burton, Henninger & Hafetz, 2005; Kolb & Whishaw, 2001; Mildner, 2008; Weiss et al., 2003). In addition, they usually present faster language development (Berglund, Eriksson, & Westerlund, 2005; Hoff, 2001; Fenson et al., 1994; Morley, 1957), have a broader vocabulary, more accurate speech production, and greater fluency (Kolb & Whishaw, 2001; Mildner, 2008; Pinker, 2007; Sommer, Aleman, Sommer, Boks & Kahn, 2004). Finally, an advantage in favor of women has also been reported on word list learning tasks (Kramer, Delis & Daniel, 1988).

Despite the aforementioned reports, gender differences in language abilities remain a controversial topic, as not all of the research carried out supports the assumption of higher verbal abilities in women. Hyde and Linn (1988), for example, conducted a meta-analysis of 165 language studies involving both children and adults and including a broad range of language tests (vocabulary, analogies, anagrams, reading comprehension, speaking or other verbal communication, essay writing, the Scholastic Aptitude Test (SAT)-Verbal, and general verbal ability tests). Results were mixed: forty-four (27%) of the studies reported that females outperformed males, 109 (66%) found no significant gender differences, and 12 (7%) found males outperforming females. The authors concluded that “the magnitude of the sex difference in verbal ability is currently so small that it can effectively be considered to be zero” (Hyde & Linn, 1988, p. 64). Recently, Wallentin (2009) performed an extensive review of gender differences in language among children, which reached the conclusion that, “A small but consistent female advantage is found in early language development. But this seems to disappear during childhood. In adults, sex differences in verbal abilities and in brain structure and function related to language processing are not readily identified. If they exist, they are not easily picked up with the research methods used today” (p. 181).

Gender disparities related to spatial abilities have been reported more consistently than those associated with verbal skills. In most cases, men outperform women in such spatial tasks as navigations strategies and geographical orientation (Iachini, Sergi, Ruggiero & Gnisci, 2005; Dabs, Chang, Strong, & Milun, 1998; Delgado & Prieto, 1996; Driscoll, Hamilton, Yeo, Brooks & Sutherland, 2005; Parsons et al., 2004; Rilea, Roskos-Ewoldsen & Boles, 2004). However, the size of these effects is usually small and varies according to age and the testing procedure involved. Vogel (1990) reports that a re-analysis of earlier research shows that, although differences in visual-spatial ability were significant, the gender distinction did not account for more than 1% to 5% of the group variance.

Gender differences in mathematical skills have aso been reported with some frequency (e.g., Benbow, Libinski, Shea, & Eftekhari-Sanjani, 2000; Benbow & Stanley, 1983; Rosselli, Ardila, Matute & Inozemtseva, 2009). Results have shown few differences in average achievement in mathematics according to gender in the fourth-to-eighth grade levels, but a substantial gender variation in achievement in mathematics among students in the final year of high school (Mullis et al., 2000). The largest differences have been found in gifted populations, where males outperform females by approximately half a standard deviation (Benbow, 1988; Benbow & Stanley, 1983). Usually, no gender differences in primary mathematical abilities (i.e., those found in every culture) are reported, but gender disparities in secondary mathematical domains (i.e., those that emerge primarily in the school environment), have been reported in many different countries around the world (Klein, & Starkey, 1988; Mullis et al., 2000), with males consistently outperforming females in such areas as solving mathematical word problems and geometry (Geary, 1996). In 2003, the National Average SAT-M scores were 537 and 503 for boys and girls, respectively (www.cde.state.co.us/cdeassess/ results/ 2003/ SAT_Data.pdf). According to these general scores on the SAT test, the average difference between boys and girls hovered around the 6% range.

Interestingly, women seem to perform better on tests of psychomotor speed and accuracy (Majeres, 1988, 1990), perceptual speed, and fine motor skills (Watson & Kimura, 1991), though this latter gender difference has been discussed much less frequently in the literature.

The origin of these differences is not yet clear, though it has been assumed that both biological and environmental factors account for the variation that has been demonstrated. Among the biological factors identified, differences in neurological structure and function have been pointed out (e.g., Blanch, Brennan, Condon, Santosh, & Hadley, 2004; Luders, Narr, Thompson, Rex, Jancke, Steinmetz, & Toga, 2004; Rilea, Roskos-Ewoldsen, & Boles, 2004). Some authors have found that hormones are associated with certain aspects of brain differentiation (e.g., Aleman , Bronk, Kessels, Koppeschaar, & van Honk, 2004; Burton, Henninger, & Hafetz, 2005; Driscoll, Hamilton, Yeo, Brooks, & Sutherland, 2005; Gouchie & Kimura, 1991). The androgens and ovarian hormones (estrogen and progesterone) have traditionally been considered important in terms of sexual differentiation, and the existence of two sensitive periods in which these differences are induced is widely accepted. The first period is recognized as organizational, when significant and permanent structural changes occur in the brain. In this period, the sensitivity of the brain to circulating hormones is stimulated. High or low steroid hormonal levels during prenatal development determine and induce these changes, which are related to morphological, anatomical and functional differences between the brains of women and men. The second period is characterized by the effect of circulating hormones on behavior, which has been called the activational effect. In this second period, hormones cannot produce permanent changes in the central nervous system, though they can induce the initiation of previously absent sexual or non-sexual behaviors (Gagnidze & Pfaff, 2009; Wu et al., 2009).

Sex differences in cognitive abilities have also been related to environmental influences, educational background, and cultural idiosyncrasies (e.g., Quaiser-Pohl & Lehmann, 2002). Ostrosky et al. (1985, 1986) reported that gender differences in the cognitive abilities that are usually measured in neuropsychological tests show a significant interrelation with educational levels: The differences in test scores between men and women appear only in subjects with low educational levels, disappear progressively as educational levels increase, and cease to appear in subjects with approximately 10 years of schooling or more. According to Ostrosky and colleagues, in participants with limited education or no schooling whatsoever, men outperform women in virtually all of the cognitive domains (including language) studied. In participants with medium or higher levels of education, performance in different cognitive domains (including spatial abilities) is identical in the two genders. This interaction between gender and educational level has been found persistently in a variety of studies carried out in Mexico and Colombia (e.g., Ostrosky et al., 1985; Ostrosky-Solis, Ardila & Rosselli, 1999; Rosselli & Ardila, 2003). Although no clear explanation for this interaction has yet been advanced, it has been suggested that in conditions of low educational levels men are exposed to a significantly richer environmental stimulation. Whereas women frequently remain at home where they care for their children and do the cooking and cleaning, men participate in diverse activities that require moving around the city, handling money, interacting with a variety of people and receiving a constant flow of information on many social and political events.

Some authors have emphasized the dispersion in cognitive abilities between men and women rather than just the mean gender differences. For example, based on analyses of mental test scores from different studies, Hedges and Nowell (1995) argued that although average sex differences have generally been small and stable over time, the test scores of males have consistently shown greater variance. Moreover, with the exception of tests of reading comprehension, perceptual speed, and associative memory, males typically outnumber females substantially among high-scoring individuals.

Most of the literature concerning gender differences in cognition focuses on young adults, and few studies have approached the question of gender differences during cognitive development. For example, Bornstein, Han and Haynes (2004) selected 329 children from 1 to 6 years of age for four longitudinal studies of specific and general language performance. Language performance at each age and the stability of individual differences across age in girls and boys were assessed separately and together. In the second through fifth years, but not before or after, girls consistently outperformed boys in multiple specific and general measures of language, suggesting that gender differences in this area are restricted to a narrow age range. Nichelli, Bulgheroni and Riva (2001) presented developmental data for verbal and spatial memory tasks (Corsi's block-tapping test and Luria's verbal learning test) for 275 children aged from 5 years-4 months to 13 years-6 months. No significant sex difference was found, though a slight trend in verbal span favoring female subjects was present. Ardila and Rosselli (1994) used a neuropsychological battery (Boston Naming Test, Token Test, verbal fluency, Wechsler Memory Scale, Rey-Osterrieth Complex Figure, and recognition of superimposed Poppelreuter-type figures) in a study of 233 normal children aged from 5 to 12 years. No evident gender differences were reported. Fenson et al. (1994) studied 1803 sociodemographically diverse 1- and 2-year-old American children, who were first assessed by their mothers using a checklist questionnaire paradigm. Significant effects of gender were found in both 1- and 2-year olds on both vocabulary comprehension and vocabulary production, with girls scoring significantly higher than boys; however, the differences found were very small, accounting for just 1%–2% of the variance.

Iijima, Arisaka, Minamoto, and Arai (2001) found differences between drawings made by boys and girls aged 5 to 6 years. Especially marked contrasts were noted in the use of motifs and colors. Girls drew people, flowers, butterflies , the sun, houses and buildings, and trees using warm colors more frequently than did boys. In contrast, boys liked to draw mobile objects such as vehicles, trains, aircrafts and rockets, using cold colors. Generally, girls used more colors per drawing as compared to boys. In the same vein , Hampson, Rovet and Altmann (1998) found that boys (10.3 years old) outperformed girls (10.5 years old) on a spatial reasoning test, but did not register gender differences in a perceptual speed task, where differences between men and women have traditionally been reported.

In summary, gender differences in children’s cognitive abilities remain an area of controversy. Whereas some studies have found such differences, others have failed to isolate them. There is no question that additional analyses of the potential gender differences in cognitive development using a large sample with an ample age range are needed and may help to clarify the interaction between gender and age in relation to cognition. The present study analyzes gender differences in a large sample of Spanish speaking children using the attention, perceptual, language, metalingusitic awareness, memory (coding), constructional and spatial subtests of the ENI (*Evaluación Neuropsicológica Infantil* –Child Neuropsychological Assessment, Matute, Rosselli, Ardila & Ostrosky-Solis, 2007). The performance of boys and girls in 7 cognitive domains was compared across 6 age groups that ranged from 5 to 16 years of age. Based on previous findings, the researchers expected that girls would outperform boys on verbal tasks, while boys were expected to perform better on spatial tasks. A Gender x Age interaction was also anticipated in these tasks. No significant gender differences were expected in any of the other cognitive tests applied.

Discussion

The results of this study support the assumption that gender differences in language and other cognitive abilities are usually non-significant or very small; indeed, gender differences were found only in three domains: language (but only on the Language

Expression and Language Comprehension subtests), Spatial Abilities (but only on the subtest of Pictures from Different Angles), and on several Sensory-perceptual tests.

Language ability differences were significant but only at a marginal level (p=.047), with a higher performance among boys than girls, though this accounted for less than 1% of the test score variance. These results are congruent with the proposal presented by Wallentin (2009) in the sense that sex differences in verbal abilities within the normal population are very low or perhaps non-existent. It is noteworthy that boys had higher scores than girls, as this contradicts the widely accepted idea that language abilities are higher among females (e.g., Burton, Henninger & Hafetz, 2005; Kolb & Whishaw, 2001; Mildner, 2008; Pinker, 2007; Sommer, Aleman, Bouma, & Kahn, 2004; Weiss et al., 2003).

Gender differences in Spatial Abilities were found only on one subtest (Pictures from Different Angles), where boys performed better. For the other four subtests included in this ENI section, no gender differences appeared. The difference between boys and girls in the Pictures from Different Angles test accounted for about 2.5% of the score variance. The subtest of Pictures from Different Angles is indeed a visual-perceptual and mental rotation ability test (the child must recognize the position of drawings of objects that are viewed from the right, left, front, back, or above). Gender differences in spatial and mechanical abilities have been reported frequently in the literature (Iachini, Sergi, Ruggiero & Gnisci, 2005; Dabs, Chang, Strong, & Milun, 1998; Delgado & Prieto, 1996; Driscoll, Hamilton, Yeo, Brooks & Sutherland, 2005; Parsons et al., 2004; Rilea, Roskos-Ewoldsen & Boles, 2004). For instance, Lynn (1992) studied gender differences on the eight tasks of the Differential Aptitude Test (Bennett, Seashore & Wesman, 1990) in approximately 10,000 13-18-year-old participants in the United Kingdom. That experiment found that males obtained higher means on five of the tests (Verbal Reasoning, Abstract Reasoning, Numerical, Mechanical Reasoning, and Spatial Relations), while females obtained higher means on the tests of Clerical Speed and Accuracy, Spelling, and Language. The study by Bennett et al. suggests the existence of a clear gender difference in terms of mechanical and spatial relations skills. However, despite its apparently solid nature, that difference accounted for only 2.5% of the variance; thus supporting Vogel's (1990) proposal that gender differences in visual-spatial ability do not account for more than 1% to 5% of group variance.

A gender effect was also observed in the Sensory-perceptual tests with boys outperforming girls in the visual, but girls outperforming boys on the tactile tasks. Differences between boys and girls on these tests accounted for approximately 1% to 2% of the score variance.. Consistent with our findings, comparisons of males and females in visual organization tasks (e.g., Hooper's Visual Organization test) have described boys performing better than girls (Kirk, 1992). However, such an association with gender has not always been found in visual tests (Merten & Beal, 1999).

Our results also showed a significant age-by-gender interaction on the tactile tests. Girls significantly outperformed boys on the tactile tasks at younger ages but no gender differences were observed in the oldest group. Unfortunately, few studies have examined gender differences on tactile discrimination tasks among children, though Borgo, Semenza and Puntin (2004) did find gender disparities in the dichaptic scanning of verbal and spatial material. Recent findings in adults have suggested the presence of gender differences in motor programs used for exploration in manipulospatial tasks, such as tactile discrimination with active touching (Sedato, Ibanez, Deiber, & Hallet, 2000). Those authors speculated that the differences were possibly due to a greater interhemispheric interaction in women than in men. Also, gender effects across somatosensory test parameters have recently been reported. Girls tended to be more sensitive than boys to thermal stimuli and pressure pain stimuli (Blankenburg et al., 2010).

It is important to note that although the differences were small, in most tests where variation between the two genders was found, performance was higher in boys than in girls. This observation suggests the possibility that certain cultural factors may potentially account for these differences. Specific gender attitudes and values may result in increased or decreased motivation to obtain high test scores. Boys may be more competitive than girls and hence, expectations may be higher for the former than the latter. Consequently, boys may pay more attention and strive more determinedly to obtain optimal performance. It has been established that gender differences in competitiveness vary across cultures (Gneezy, Leonard & List, 2009). In Latin American societies, for example, indices of competition have been found to be higher in boys than in girls (Schneider, Woodburn, Soteras del Toro & Udvari, 2005). It is important to emphasize that in most tests, a significant Age X Gender interaction was absent; a finding that supports the suggestion that these gender differences are age-independent and may represent a constant characteristic of males in the societies where the participants were recruited. Noteworthy, Hyde and Mertz (2009) observed that gender inequality is a cross-cultural predictor of gender differences in mathematics performance.

In summary, our results indicate the existence of a larger number of gender similarities than gender differences across a relatively large age range (5 to 16 years), and using a relatively large sample of children (788 participants). This supports the assumption that gender differences during cognitive development are minimal, appear in only a small number of tests, and account for only a low percentage of the score variance. It is likely, therefore, that certain cultural factors may be responsible for at least some of the gender differences that appear in test scores. One limitation of the current study is that the domains used as dependent measures cannot be considered to be underlined by unique cognitive factors as indicated by the factor analyses. Future research should confirm null results of gender differences in cognitive tasks with unique underlying cognitive processes.

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