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Cognitive sex differences in reasoning tasks: Evidence from Brazilian samples of educational settings

Carmen Flores-Mendoza [a,*], Keith F. Widaman [b], Heiner Rindermann [c], Ricardo Primi [d], Marcela Mansur-Alves [a], Carla Couto Pena [a]

[a] Department of Psychology, Universidade Federal de Minas Gerais, Belo Horizonte, Minas Gerais, Brazil
[b] Department of Psychology, University of California, Davis, USA
[c] Department of Psychology, Technical University Chemnitz, Germany
[d] Department of Psychology, Universidade São Francisco, Itatiba, São Paulo, Brazil

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ABSTRACT

Sex differences on the Attention Test (AC), the Raven's Standard Progressive Matrices (SPM), and the Brazilian Cognitive Battery (BPR5), were investigated using four large samples (total $N=6780$), residing in the states of Minas Gerais and São Paulo. The majority of samples used, which were obtained from educational settings, could be considered a nonprobability sampling. Females outperformed males on the AC (by 2 IQ points), whereas males slightly outperformed females on the SPM (by 1.5 IQ points). On the BPR5, sex differences favoring males were statistically significant (on average 6.2 IQ points). The largest difference was in Mechanical Reasoning (13 IQ points), and the smallest was in Spatial Reasoning (5 IQ points). In addition, two methods were adopted for determining whether sex differences existed at the level of general intelligence. First, a *g* factor score was estimated after principal axis factoring of test scores. Men had an advantage of 3.8 IQ points (statistically significant) on the *g* score, which was reduced to 2.7 IQ points (not significant), when the *g* score was estimated without including Mechanical Reasoning. Second, a confirmatory factor analysis approach was conducted that allowed testing of mean differences at the latent variable level. Again, sex differences favoring males were found (0.23 or 3.44 IQ points). Regarding educational and SES variables, some sex differences favoring males were found in the SPM and in the BPR5. In general, our results agree with studies that identify small, but consistent cognitive sex differences in reasoning tasks. Societal implications are discussed.

1. Introduction

Some topics in the social and behavioral sciences are difficult and controversial due to the political and societal consequences and implications of the empirical results obtained. Research on cognitive sex differences is one such topic. Discussions regarding sex differences began in the early 20th century, when the first investigations were recorded negatively in books such as, "The mental inferiority of woman", written by the German physiologist Moebius (Andrés-Pueyo & Zaro, 1998). Since then, a myriad of investigations, including more technical and less prejudiced and political, have highlighted whether cognitive sex differences really exist. Empirical results accumulated to date suggest that the final answer is still far from being achieved.

Scientific uncertainty regarding cognitive sex differences arises from the vast accumulation of evidence that men and women may be reliably different on specific dimensions of ability. However, whether the sex differences can reliably be identified at the level of general intelligence is a matter that has

* Corresponding author at: Av. Antonio Carlos, 6627, Fafich, Depto. de Psicologia, Gab. 4042, Universidade Federal de Minas Gerais, CEP 31330-030, Brazil.
E-mail addresses: carmencita@fafich.ufmg.br, carmenflor@uol.com.br (C. Flores-Mendoza), kfwidaman@ucdavis.edu (K.F. Widaman), heiner.rindermann@psychologie.tu-chemnitz.de (H. Rindermann), ricardo.primi@saofrancisco.edu.br (R. Primi), marcelamansuralves@yahoo.com.br (M. Mansur-Alves), carlacouto@magnum.com.br (C.C. Pena).

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not yet been resolved. Sex differences are often reported as standardized effect sizes based on mean differences between groups. These effects are usually calculated using Cohen's d, calculated as $d = (M_m - M_f)/S$, where M_m is the mean of the male sample, M_f is the mean for the female sample, and S is the pooled data within-group standard deviation. Thus, Cohen's d indicates the number of SD units of difference in mean performance between males and females. With regard to specific ability dimensions, reported d values (where negative values indicate females scored higher than males), vary considerably across studies and domains of mental ability. For instance, Hyde (1981) and Hyde and Linn (1988) found $d = -0.24$ and $d = -0.15$ respectively in verbal tasks, thus differences favoring females. Jensen (1998) asserted that women outperform men in perceptual speed and short term memory (d values -0.20 and -0.30, respectively), whereas Colom, Quiroga, and Juan-Espinosa (1999), using data from the *Differential Aptitude Tests* (DAT), found women were slightly better in speed ($d = -0.08$) and accuracy ($d = -0.05$). In addition, Colom et al. found higher female scores in vocabulary ($d = -0.03$), verbal fluency ($d = -0.01$), and inductive reasoning ($d = -0.038$), using 1995 normative data of *Primary Mental Abilities* (PMA). On the other hand, Linn and Petersen (1985) found $d = 0.73$ in rotation tasks and $d = 0.44$ in spatial relations tasks, thus favoring males. Voyer, Voyer, and Bryden (1995) reported similar results. Colom et al. (1999) found higher scores for males in Verbal Reasoning ($d = 0.31$), Numerical Ability ($d = 0.59$), Abstract Reasoning ($d = 0.39$), Spatial Relationships ($d = 0.39$), Mechanical Reasoning ($d = 1.14$), calculation ($d = .57$), and Mental Rotation ($d = 0.36$).

More recently, Geiser, Lehmann, and Eid (2008), reported evidence of sex differences favoring males in mental rotation at different ages (ranging from 9 to 23 years), with d values varying from 0.52 to 1.49. In another study, van der Sluis et al. (2008), analyzing sex differences in the WISC-R in Dutch children (ages 11 to 13 years) and Belgian children (ages 9.5 to 13 years), found that girls outperformed boys on the Coding subtest ($d = -0.53$ and $d = -0.53$, for Dutch and Belgians, respectively), whereas boys outperformed girls on the Information ($d = 0.52$ and $d = 0.37$, for Dutch and Belgians, respectively) and Arithmetic subtests ($d = 0.31$ and $d = 0.19$, for Dutch and Belgians, respectively). Also, Liu and Lynn (2011) analyzed samples of children (ages 5 to 6 years) from China, Japan, and the USA, assessed with the Wechsler Preschool and Primary Scale and found significant sex differences favoring boys on Information ($d = 0.19$, China), Vocabulary ($d = 0.20$, China), Arithmetic ($d = 0.14$, China), Comprehension ($d = 0.23$, China), Picture Completion ($d = 0.11$ for China and $d = 0.21$ for Japan), and Mazes ($d = 0.35$ for China and $d = 0.33$ for Japan). The only sub-test in which girls significantly outperformed boys was Animal House (a non-verbal test) for Japanese ($d = -0.36$) and USA ($d = -0.31$) samples.

Therefore, considering published research, little doubt remains that men and women, in fact, differ in their specific cognitive abilities. Moreover, some abilities appear to differentiate males and females in a consistent way. For instance, considering mean differences on a distribution across the sexes, women outperform men in tasks that require semantic processing, perceptual speed, and verbal memory (Codorniu-Raga & Vigil-Colet, 2003; Halpern, 1997; Johnson & Bouchard, 2007; Lubinski, 2004; Lynn, Raine, Venables, Mednick, & Irwing, 2005; Maccoby & Jacklin, 1974); whereas men demonstrate superior performance to that of women in visual–Spatial tasks, abstract reasoning, and numerical reasoning (Colom et al., 1999; Hyde, Fennema, & Lamon, 1990; Hyde & Linn, 1988; Linn & Petersen, 1985; Voyer et al., 1995). In general, similar results have been observed, with few exceptions, in children and adult samples and in populations from developed or from developing countries (Dai & Lynn, 2001; Dai, Ryan, & Harrington, 1991; Echavarri, Godoy, & Olaz, 2007; Flores-Mendoza, Mansur-Alves, Lelé, & Bandeira, 2007).

In contrast, this “relatively stable” pattern of differential sex differences, particularly in cognitive abilities, has not been observed in investigations regarding general intelligence. Conceptually, general intelligence (also called “g”) is defined as a broad mental ability for reasoning, planning, resolving problems, thinking abstractly, and learning from experiences (Gottfredson, 1997; Hunt, 2011; Lubinski, 2004; Nisbett et al., 2012). Thus, g would be an important psychological attribute for human survival and adaptation to any context, as well as for maintaining personal success across a lifetime. Specific cognitive abilities, especially those with lower loading of g, would not have the same degree of general importance in survival and adaptation due to the narrow range of application of the specific abilities. Therefore, a consistent finding in differences among human groups at the level of g would imply that one group has a greater likelihood of successful adaptation than another group in its capacity for dealing, in a global way, with the challenges present in their physical and social contexts. Because of the perceived importance of g for successful adaptation and success in life, laypersons and experts pay special attention to the results of investigations of sex differences in the general intelligence.

Studies of sex differences in general intelligence are aligned within two academic camps. The first, asserts a male advantage in general intelligence. Studies by Lynn and his colleagues (Lynn, 1999, 2002; Lynn, Allik, Pullmann, & Laidra, 2004; Lynn, Backhoff, & Contreras-Niño, 2004; Lynn, Fergusson, & Horwood, 2005) clearly support this position, which confers a male advantage of 0.26 SD units, which corresponds to a sex difference of approximately 4 points on the well-known IQ metric. Other researchers (Jackson & Rushton, 2006; Nyborg, 2003, 2005) have arrived at similar results. According to Lynn, biological bases might explain these differences insofar as developmental sex differences are observed. Females do better at younger ages, but males obtain higher scores after they achieve biological maturation, around 16 years of age (Lynn, 1999), which is later than females. This idea is not new and can be tracked across the first studies of mental abilities published during the past century (e.g., Conrad, Jones, & Hsiao, 1933).

The second position, in contrast to the first, maintains that no sex difference in general intelligence exists (Aluja-Fabregat, Colom, Abad, & Juan-Espinosa, 2000; Codorniu-Raga & Vigil-Colet, 2003; Colom, Juan-Espinosa, Abad, & García, 2000; Dolan et al., 2006; Johnson & Bouchard, 2007; Mackintosh, 1996; van der Sluis et al., 2006, 2008). According to this position, sex differences found in some studies reflect, in fact, differences in “intelligence in general” (which refers to a combination of g + a mixture of specific cognitive abilities) instead of differences in “general intelligence” (or g). A major summary commissioned by the American Psychological Association endorsed this position (Neisser et al., 1996), as did a recent review of that summary (Nisbett et al., 2012).