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Gender differences in latent cognitive abilities in children aged 2 to 7

Mohammed H. Palejwala *, Jodene Goldenring Fine

Michigan State University, USA

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ABSTRACT

Gender differences in the latent cognitive abilities underlying the Wechsler Primary and Preschool Scale of Intelligence—Fourth Edition (WPPSI-IV) were investigated in children aged 2 to 7. Multiple-group confirmatory factor analysis was used to verify the measurement invariance of the WPPSI-IV factor model in boys and girls. Then the magnitude of gender differences in the means and variances of the abilities was estimated. Multiple-indicator multiple-cause models were implemented to explore whether the magnitude of these differences varied across age. Girls aged 2 to 7 demonstrated higher general intelligence. Girls aged 4 to 7 demonstrated an advantage in processing speed. A gender difference favoring boys in visual processing was absent in ages 2 to 3 but emerged in ages 4 to 7. Gender differences in fluid reasoning, short-term memory, and comprehension-knowledge were not found. The variability of any of the abilities did not differ among girls and boys. These results indicate that gender differences in cognitive abilities emerge in early childhood, which may contribute to gender differences in later educational outcomes.

1. Introduction

The research on gender differences in cognitive abilities is marked by inconsistency. Even for those gender differences receiving consistent support in adults (e.g. a male advantage in visual–spatial ability), the age at which these differences emerge in childhood is unclear. The purpose of the present study is to investigate gender differences in cognitive abilities in children aged 2 to 7 years with the goal of determining when these differences appear. The instrument used to examine gender differences is the fourth edition of the Wechsler Primary and Preschool Scale of Intelligence (WPPSI-IV), one of the most widely used measures of intelligence for young children (Raiford & Coalson, 2014). The following section discusses the factors that explain inconsistencies in the literature on gender differences in cognitive abilities. Methodological differences among studies along with population heterogeneity may contribute to discrepancies in the extant literature.

1.1. Inconsistencies in previous research

Researchers have historically examined gender differences by comparing male and female scores on single tests or composites of multiple tests. These types of scores are referred to as observed scores. Observed scores contain measurement error and unique variance. In contrast, latent variables are estimates of cognitive abilities using structural equation modeling that remove these sources of unreliability and invalidity. Latent variables are less influenced by the mix of tests used to estimate them and are considered to be purer measures of the construct of interest. Studies using both observed and latent variable methods to examine gender differences in the same data set have shown that these methods produce different conclusions (Härnqvist, 1997; Steinmayr, Beauducel, & Spinath, 2010), supporting the need to use a latent variable approach to investigate gender differences in cognitive abilities.

* Corresponding author at: Michigan State University, 435 Erickson Hall, East Lansing, MI 48824-1034, USA. Tel.: +1 517 432 1683.
E-mail addresses: palejwal@msu.edu (M.H. Palejwala), finej@msu.edu (J.G. Fine).

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Another advantage to using a latent variable methodology is that one can investigate the assumption that a test measures constructs in the same way across groups. This assumption is called measurement invariance and is a prerequisite to comparing scores reflecting the constructs. Studies examining the measurement invariance of cognitive ability tests across gender have sometimes found that the instruments only partially meet criteria for measurement invariance (Immekus & Maller, 2010; Keith, Reynolds, Roberts, Winter, & Austin, 2011). Therefore, measurement invariance of a cognitive test battery across gender should not be assumed and needs to be examined before comparing male and female scores on the battery.

Cognitive tests may not only measure a construct differently between groups, but additionally they may not always measure the ability that they intend to measure. Discrepancies in the literature on gender differences in cognitive abilities may arise from discrepancies in how cognitive abilities are operationalized. One frequently used theory for operationalizing the cognitive abilities that intelligence tests measure is Cattell–Horn–Carroll (CHC) theory (Keith & Reynolds, 2010). CHC theory is a taxonomy of cognitive abilities based on factor analysis of more than 460 data sets and is arguably among the best supported taxonomies of cognitive abilities (McGrew, 2009).

CHC theory defines cognitive abilities at three levels, or strata, of generality. The lowest level describes cognitive abilities with the most specificity and consists of more than 50 abilities called narrow abilities (stratum I). The narrow abilities can be classified into at least 7 abilities, which are called broad abilities (stratum II). The highest level describes cognitive abilities at the most general level and consists of one ability: general intelligence, or g (stratum III). The structure of CHC theory can be described by a second-order factor model, in which the broad abilities account for covariation among the narrow abilities, and g accounts for covariation in the broad abilities. Because the structure of the current version of the instrument used in this study is based on CHC theory, and it is a well-supported theory, it is used to define the cognitive abilities measured in this study.

Another methodological difference that may explain discrepancies in the gender differences literature is whether or not researchers account for g when comparing males and females on specific abilities. If g is not accounted for, gender differences in specific abilities may in reality reflect differences in general cognitive development. For this reason, g is controlled in the current study. Studies have found that the magnitude of gender differences in specific abilities can vary before and after controlling g, underlining the need to account for g in this type of investigation (Burns & Reynolds, 1988; Kaiser & Reynolds, 1985).

A non-methodological difference that likely contributes to discrepancies in the literature is population heterogeneity. Specifically, gender differences in cognitive abilities vary by age. Cross-sectional studies have found that gender differences in cognitive abilities measured by the same instrument emerge and diminish across the lifespan (Keith, Reynolds, Patel, & Ridley, 2008; Keith et al., 2011; Reynolds, Keith, Ridley, & Patel, 2008). These studies used instruments that demonstrate measurement invariance across ages, so the change in gender differences in cognitive abilities cannot be attributed to a change in the way the abilities are measured.

Based on this overview of the factors that contribute to discrepancies in the literature on gender differences in cognitive abilities, the strongest studies: (a) verify that their instrument measures cognitive abilities in the same way across gender, (b) estimate abilities at the latent variable level, (c) use an empirically-supported theory to define the cognitive abilities their instrument measures, (d) control for g, and (e) investigate whether the magnitude of gender differences varies developmentally if their sample represents a wide developmental span. The next section reviews the literature on gender differences in cognitive abilities and emphasizes the results from studies that meet these criteria.

1.2. Gender differences in cognitive abilities: an overview

Contemporary models of CHC theory propose the existence of at least seven broad cognitive abilities (Schneider & McGrew, 2012). The WPPSI-IV, the instrument used to investigate gender differences in this study, is designed to measure g and the following five broad cognitive abilities: comprehension-knowledge (Gc), visual processing (Gv), fluid reasoning (Gf), short-term memory (Gsm), and processing speed (Gs). For this reason, the current review of the gender differences literature is restricted to these five broad abilities and g, with special emphasis on young children.

1.2.1. Mean differences

Because of the power of general intelligence (g) to predict educational and occupational outcomes (Jensen, 1998), researchers have paid significant attention to gender differences in the mean of g. Studies that have investigated gender differences in g in children aged 5 to 17 using a latent variable approach generally support a null difference (Keith et al., 2011; Reynolds, Keith, Flanagan, & Alfonso, 2013) or an advantage for girls (Härnqvist, 1997; Reynolds et al., 2008; Rosén, 1995). Only a small number of studies offer information about gender differences in g in children younger than five, and these studies are limited in that they use an observed variable approach. Sellers, Burns, and Guyrke (2002) did not detect a gender difference in g in children aged 3 to 7 in the standardization sample of the WPPSI-R. In contrast, Burns and Reynolds (1988) discovered a gender difference in g favoring females aged 2 to 4 on the Kaufman Assessment Battery for Children (Kaufman & Kaufman, 1983). In general, the research in children generally points to the absence of a gender difference in g or a female advantage.

At the level of the broad abilities, the mean gender difference that has received the most attention is the male advantage in Gv. Although a large volume of research supports a male advantage in Gv (Härnqvist, 1997; Keith et al., 2011; Reynolds et al., 2013; Reynolds et al., 2008; Rosén, 1995), the age at which this gender difference emerges is not evident, even when only considering studies using a latent variable approach. For example, one latent variable study suggests that the male advantage emerges at least by age 6 (Reynolds et al., 2008), whereas another latent variable study suggests that it does not emerge until age 18 (Keith et al., 2008). Studies using a latent variable approach to investigate gender difference in Gv have not included children younger than five. Other studies of young children using less robust methods have typically focused on observed scores of narrow Gv abilities. For this reason, more research that investigates