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Sex differences in latent cognitive abilities ages 5 to 17: Evidence from the Differential Ability Scales—Second Edition ☆

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ABSTRACT

Sex differences in the latent general and broad cognitive abilities underlying the Differential Ability Scales, Second Edition were investigated for children and youth ages 5 through 17. Multi-group mean and covariance structural equation modeling was used to investigate sex differences in latent cognitive abilities as well as changes in these differences across age. Most broad abilities showed mean differences across the sexes, and all such differences varied across ages. Girls showed an advantage on the processing speed (Gs) first-order residual factor. Girls also showed advantages at some ages on free-recall memory, a narrow ability of long term retrieval (Glr). Boys showed a developmentally-related advantage on a visual–spatial ability (Gv) first-order residual factor, depending on age. Younger girls showed an advantage on short-term memory (Gsm). No statistically significant sex differences were shown on the latent comprehension-knowledge (Gc) factor, or on a second-order, latent *g* factor. Boys showed larger variances for several broad abilities, some substantial, but those differences were not statistically significant.

Research on sex differences, or similarities, in cognitive abilities has a history rife with controversy. Much of the controversy arises from different theoretical explanations about why sex differences may emerge. Inconsistent empirical findings make it confusing, and only add to the controversy. Nevertheless, inconsistent findings may also improve understanding by forcing researchers to take a more critical and careful examination of how to analyze their data. Despite inconsistent findings, a few fairly consistent and more robust patterns have seemed to emerge across tests, samples, and methodologies (e.g., controlling for *g* versus not controlling for *g*; using latent variables versus composite variables).

In the brief review of research that follows, a Cattell–Horn–Carroll (CHC) perspective will be used to categorize and discuss findings (Newton & McGrew, 2010). There are several reasons we used this approach. First, CHC nomenclature provides a useful taxonomy for categorizing both narrow and broad cognitive abilities (Schneider & McGrew, in press). Second, that approach has been shown to describe consistently the abilities measured by a broad range of intelligence measures, whether those measures were developed based on CHC theory or some other theoretical orientation (or no theoretical orientation) (Keith & Reynolds, 2010). Third, the test used in this research was based, in part, on CHC theory.

1. Sex differences in broad abilities

When sex differences in processing speed (Gs), the ability to perform simple or overlearned cognitive tasks quickly, has

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been evaluated, females have shown a consistent advantage in Gs across studies using either latent variables or composite scores (Burns & Nettelbeck, 2005; Camarata & Woodcock, 2006; Hedges & Nowell, 1995; Irwing, in press; Keith, Reynolds, Patel & Ridley, 2008; Lynn, Fergusson, & Horwood, 2005; van der Sluis et al., 2006). This female advantage appears to become larger as children approach middle school and high school ages (Camarata & Woodcock, 2006; Hulick, 1998), and it continues through adulthood (Keith et al., 2008). Similarly, across study methodologies, males generally showed an advantage in visual–spatial abilities (Gv) (Härnqvist, 1997; Jensen, 1998; Keith et al., 2008; Rosén, 1995); although Camarata and Woodcock (2006) did not find a male advantage when using a composite variable. This general advantage in Gv for males seems to emerge in childhood and continue through adulthood.

Findings for other broad abilities are less consistent. Some studies using latent variables have found no sex difference in short term memory (Gsm), long term retrieval (Glr), or auditory processing (Ga) (Keith et al., 2008; Reynolds, Keith, Fine, Fisher & Low, 2007). In other studies and reviews, however, a female advantage in Ga (Hulick, 1998), Gsm (Jensen, 1998; Maitland, Intrieri, Schaie & Willis, 2000) and Glr (Hedges & Nowell, 1995; Johnson & Bouchard, 2007) has been noted. There has also been a male advantage found in working memory (MW) (Dolan et al., 2006; van der Sluis et al., 2006), although the working memory factor in this research may include aspects of quantitative reasoning, as well (Benson, Hulac, & Kranzler, 2010; Keith, Fine, Taub, Reynolds, & Kranzler, 2006).

Research has shown inconsistent differences in fluid reasoning (Gf). Recent findings regarding the presence of sex differences across ages in Gf have favored neither sex (Camarata & Woodcock, 2006; Kaufman & Horn, 1996; Keith et al., 2008; Keith, Reynolds, Patel & Ridley, 2008). Studies by Lynn and colleagues, however, have suggested a male advantage in Gf, as measured by Raven's Progressive Matrices, in late adolescence and adulthood (Lynn, Allik & Irwing, 2004; Lynn & Irwing, 2004a, b). Last, others have also found a male advantage in the Gf narrow ability of quantitative reasoning (RQ) (Keith et al., 2008).

Research on verbal comprehension-knowledge (Gc) has also produced varied results, although rather than the broad Gc ability, sex differences may be found on more specific or narrow aspects of Gc. Males have demonstrated higher scores on measures of verbal analogies and general knowledge, whereas females have demonstrated higher scores on measures of general verbal ability and word knowledge (Hyde & Linn, 1988; Lynn, Irwing, & Cammock, 2001). Recent findings with latent, rather than composite, variables revealed a small, consistent male advantage across ages 6 through 59 (Keith et al., 2008) and ages 6 to 16 (Reynolds et al., 2008) for Gc; both studies controlled for general intelligence (*g*), illustrating that it is important to control for *g* before testing for sex differences in broad or specific abilities (see Johnson & Bouchard, 2007). Nevertheless, using composite scores from the same dataset as Keith and colleagues (2008), Camarata and Woodcock (2006) also found evidence for a male advantage in Gc.

Thus, beyond the relatively consistent findings of female advantage in Gs and male advantage in Gv, it is unclear whether there are differences in the other broad (and narrow) abilities. Sample selection may play a role in differences in findings. Further, results may vary as a result of methodological differences, including measurement instruments, age levels, the estimation of mean differences via composites versus latent variables (Steinmayr, Beauducel & Spinath, 2009), and the inclusion or exclusion of *g* in the analyses (Johnson & Bouchard, 2007).

2. Sex differences in *g*

The presence and magnitude of sex differences in general intelligence (*g*) is likewise a topic of continued debate. There is mixed evidence regarding the existence of sex differences in *g* and in the presence of changes in such differences as a result of development. Some researchers have found no significant differences in *g* (or global composites) between males and females (Camarata & Woodcock, 2006; Deary, Strand, Smith & Fernandes, 2007; Deary, Thorpe, Wilson, Starr & Whalley, 2003; Jensen, 1998; Mackintosh, 1996; van der Sluis et al., 2006; van der Sluis et al., 2007). Others have found higher average levels of *g* for males (Deary, Irwing, Der, & Bates, 2006; Irwing, in press; Irwing & Lynn, 2005; Jackson & Rushton, 2006; Lynn & Irwing, 2004b; Lynn, Raine, Venables, Mednick, & Irwing, 2005; Nyborg, 2005), yet others have found possible inconsistent advantage for females in *g* that may vary with age. Rosén (1995) found a female advantage in *G* (the general intelligence factor used in nested models, that is, models in which *G* is a first-order general factor rather than a higher-order factor) only at ages 12 and 13. Härnqvist (1997) found a female advantage in *G* at ages 11 to 16 years. Arden and Plomin found higher *g* for females at ages 2, 3, 4, and 7, but found that by age 10, males were higher in *g* (2006). Reynolds and colleagues (2008) found a female *g* advantage at ages 6 to 7 and 15 to 16. Keith and colleagues (2008) found females had a higher *g* starting at age 12; but that the advantage did not become significant until age 18, and remained relatively constant from that point through adulthood.

The continued debate concerning sex differences in general intelligence highlights several possible reasons for inconsistencies in findings. First, as suggested by Lynn's theory (Lynn, 1999), sex differences in *g* may be developmental, and related to differences in growth, in general, and brain growth (and adult brain size), in particular. Some studies do indeed suggest developmental changes in *g*, although the direction of those differences has not always been in the direction expected by theory. Nevertheless, these developmental differences in *g* suggest that some of the inconsistencies in findings for broad ability differences may also be due to developmental differences.

Another possible reason for inconsistencies in findings for *g* (and other abilities) is the methodology used to estimate *g* and the broad abilities. Composites are often used to estimate *g* (and other abilities), including scaled scores, averages, and weighted composites based on principal components or factor analysis. Much of the research showing differences favoring males in general intelligence has used this approach. More recently, researchers have estimated sex differences using a latent variable approach, and that research has often (Dolan et al., 2006; Keith et al., 2008; Reynolds et al., 2008),