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Do sex differences in a faceted model of fluid and crystallized intelligence depend on the method applied?

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ABSTRACT

Recently, different methodological approaches have been discussed as an explanation for inconsistencies in studies investigating sex differences in different intelligences. The present study investigates sex differences in manifest sum scores, factor score estimates, and latent verbal, numerical, figural intelligence, as well as fluid and crystallized intelligence as measured by the German Intelligence-Structure-Test 2000-R (IST 2000-R; Liepmann, Beauducel, Brocke, & Amthauer, 2007). The not population-representative sample consisted of 977 German 11th and 12th graders enrolled in a "Gymnasium" (551 female; mean age: $M = 16.70$; $SD = 0.65$) who completed the IST 2000-R. Sex differences in fluid and crystallized intelligence were not influenced by the method applied with men performing better than women. However, extent and direction of sex differences in verbal, numerical, and figural intelligence differed by the method applied. Whereas there was a male advantage in all three factors measured as manifest sum scores, women performed better in verbal intelligence as measured by factor scores or as latent variables. Effect sizes of sex differences in numerical and figural intelligence were also greatly reduced when applying the latter two methods. Results are discussed with regard to their theoretical and practical implications.

1. Introduction

Sex differences in intelligence have been extensively investigated ever since the first intelligence tests have been introduced. Despite the substantial attention the topic has received, it is far from being thoroughly illuminated as research on sex differences in intelligence has partly produced inconsistent results concerning the presence, magnitude, and direction of the effects. Possible explanations for these inconsistencies are developmental effects (cf. Lynn, 1999), selective samples (cf. Dykiert, Gale, & Deary, 2009), and the measures used (cf. Lynn, 1999). A further explanation for the inconsistencies might be the methodological approach applied to the investigation of group differences (cf., e.g., Keith, Reynolds, Patel, & Ridley, 2008). Recently sex differences in intelligence have been investigated by multivariate latent variable approaches rather than comparing manifest intelligence test scores. An advantage of a latent variables approach is that it allows conclusions about sex differences in underlying, pure intelligence factors. Contrary to this, comparing manifest intelligence test scores might yield misleading results about the true nature of sex differences. Nevertheless, it is important to investigate sex differences in measured manifest intelligence because real world decisions, such as selection for jobs, are based on manifest intelligence test scores. The present study examines sex differences in manifest sum scores, factor score estimates, and latent verbal, numerical, figural intelligence, as well as fluid and crystallized intelligence as measured by the German Intelligence-Structure-Test 2000-R (Liepmann, Beauducel, Brocke, & Amthauer, 2007). Thus, the present study aims to compare the three methodological approaches and their impact on the emergence of sex differences.

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1.1. Sex differences in cognitive abilities

Most attention in research on sex differences in intelligence has been paid to sex differences in general intelligence. In accordance with two pioneers of intelligence testing, Terman (1916) and Wechsler (1944), it has long been proposed that there are no sex differences in general intelligence (e.g., Brody, 1992). However, this view has been challenged by different authors (e.g., Lynn, 1999; Nyborg, 2003), claiming that there are differences in general intelligence favouring adolescent and adult males. There is support for both views. Some authors found that men exceed women in general intelligence (e.g., Irwing & Lynn, 2005; Jackson & Rushton, 2006; Lynn & Irwing, 2004a,b, 2008; Nyborg, 2005) whereas others reported no sex differences (e.g., Aluja-Fabregat, Colom, Abad, & Juan-Espinosa, 2000; Colom, García, Juan-Espinosa, & Abad, 2002; Deary, Thorpe, Wilson, Starr, & Whalley, 2003; Johnson & Bouchard, 2007; van der Sluis et al., 2008). Some studies even depict a female advantage in general intelligence (e.g., Keith et al., 2008; Reynolds, Keith, Ridley, & Patel, 2008).

Considering sex differences in broad cognitive abilities such as verbal, numerical, or figural intelligence, the findings by Terman (1916) and Wechsler (1944) still seem to hold for the present day. These authors found a male advantage in more complex numerical tasks as well as in tasks requiring figural abilities. On the other hand, women received higher scores in some verbal tasks and measures of perceptual speed. These effects can largely be found in the current overview of different meta-analyses on sex differences in cognitive abilities provided by Hyde (2005). The findings of sex differences in two further broad cognitive abilities, namely fluid and crystallized intelligence, are less consistent.

Horn (1988, p. 660) depicts fluid intelligence as a "fallible indicator of reasoning of several kinds, abstracting, and problem solving, when these qualities are acquired outside the acculturation process, through personal experience, and through learning that is not selectively restricted." The author defines crystallized intelligence as follows: "The measured factor is a fallible indicator of the extent to which an individual has incorporated, through the systematic influence of acculturation, the knowledge and sophistication that can be referred to as the intelligence of a culture." (Horn, 1988; pp. 658–659) Some authors found sex differences favouring men in fluid intelligence (Lynn & Irwing, 2002, 2004a,b), whereas others found none or inconsistent results with some tests favouring men and some favouring women (Colom & García-López, 2002; Keith et al., 2008; Reynolds et al., 2008). The picture for crystallized intelligence seems somewhat more homogeneous. Most studies demonstrate men's superior performance (e.g., Ackerman, Bowen, Beier, & Kanfer, 2001; Lynn, Irwing, & Cammock, 2002; Reynolds et al., 2008; van der Sluis et al., 2006) whereas others found no sex differences (e.g., Kaufman, Chen, & Kaufman, 1995).

Possible explanations for the inconsistent results in both general intelligence and broad intelligences have been offered. Whereas developmental changes (Lynn, 1999, 1994), recruitment strategies (Dykiert et al., 2009), and operationalization of general and broad intelligences by different tests (Colom & García-López, 2002; Lynn, 1999) have already been investigated and provide some explanation for the inconsistent results, newer explanations refer to methodological considerations when investigating sex differences.

1.2. Methodological considerations

Different methodological approaches have been mentioned as a further explanation for both inconsistent results in studies investigating sex differences in general intelligence and broad cognitive abilities (e.g., Rosén, 1995; van der Sluis et al., 2006, 2008). Methodological approaches to study sex differences vary greatly. Whereas meta-analyses tend to concentrate on studies investigating sex differences by means of the standardized sum scores (e.g., Lynn & Irwing, 2004a, 2008), other studies either investigate sex differences in cognitive abilities via factor score estimates, components from factor analysis or principal components analysis (for an overview, cf. Nyborg, 2003). More recently, sex differences in latent variables are investigated by means of structural equation modelling (e.g., Dolan et al., 2006; Keith et al., 2008; Maitland, Intrieri, Schaie, & Willis, 2000; Reynolds et al., 2008; Rosén, 1995; van der Sluis et al., 2006, 2008). Depending on the method, different results might emerge.

This shall first be illustrated by means of general intelligence. According to Spearman (1904), each single test score in a multifactorial intelligence test represents general intelligence plus specific abilities and skills and measurement error specific to the particular test. From this it follows, that general intelligence (*g*) is based on the correlations among test scores and thus represents their shared variance. The standardized composite score (IQ) rests on a summation of the single test scores and thus represents *g* plus the various specific abilities and skills plus measurement error. Moreover, the summation of test scores does not take into account the relevance of the different tasks for general intelligence. Thus, depending on the method applied different results might emerge. This is in line with the findings by Colom et al. (2002) who found no sex differences in general intelligence defined as Spearman's *g* whereas males had an advantage in general intelligence defined as the sum of cognitive abilities. Consequently, when comparing any groups on an IQ score as a proxy for *g* the analysis does not allow substantive conclusions as to whether these groups differ in *g*. Mean group differences may also be due to group differences on the subtest level, indicate sex differences in broader cognitive abilities such as verbal, numerical or figural intelligence or may just reflect specifics in the measurement error related to the group but unrelated to intelligence.

The same considerations pertain to broad cognitive abilities such as verbal, numerical, or figural intelligence as well as fluid or crystallized intelligence (gf and gc). Group comparisons of these abilities are also often made on the basis of subtest scores or scales based on different subtests representing the same broad cognitive ability. According to Spearman (1904), broad cognitive ability test scores represent the focal particular broad cognitive ability, *g*, and measurement error. Johnson and Bouchard (2007) demonstrated that sex differences on subtest level greatly increased when partialling out general intelligence. The authors concluded that sex differences in specific cognitive abilities are overshadowed by *g*. Consequently it is impossible to speak about group differences in any of these abilities without