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Sex and sex-role differences in specific cognitive abilities

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ABSTRACT

Sex differences in cognitive abilities are a controversial but actively researched topic. The present study examined whether sex-role identity mediates the relationship between sex and sex-typed cognitive abilities. Three hundred nine participants (105 males and 204 females) were tested on a range of visuospatial and language tasks under laboratory conditions. Participants also completed measures of sex-role identity, used to classify them into masculine, feminine, androgynous and undifferentiated groups. While sex differences were found for some but not all measures, significant sex-role differences were found for all spatial and language measures with the exception of a novel 2D Mental Rotation Task. Masculine sex-roles partially mediated the relationship between sex and a composite measure of spatial ability, while feminine sex-roles fully mediated the relationship between sex and a composite measure of language ability. These results suggest that sex-role identity may have greater utility in explaining individual differences in cognitive performance than biological sex alone.

The topic of sex differences in cognitive abilities remains an active but controversial research question because of its educational, social and public policy implications (Eagly & Mitchell, 2004; Halpern, 2014). While most reviews find that males and females do not differ in general intelligence (Halpern, Beninger, & Straight, 2011; Jensen, 1998; cf. Nyborg, 2015) sex differences are frequently found in *specific* cognitive abilities (Nisbett et al., 2012). Robust and sizeable sex differences are found for visuospatial ability (referred herein as spatial ability) and verbal ability (Miller & Halpern, 2013). Overall, males do better on spatial tasks such as mental rotation and spatial perception (Voyer, Voyer, & Bryden, 1995), while females do better on language tasks such as verbal fluency and grammar (Halpern & Lamay, 2000; Lynn, 1992). The effect sizes are moderately large, and are reflected in beliefs about gender differences in cognitive ability (Halpern, Straight, & Stephenson, 2011).

Spatial and verbal skills are of particular interest to educational researchers for two reasons. Firstly, research suggests that spatial ability forms the basis for the development of sex differences in quantitative reasoning such as mathematics and science (Newcombe & Frick, 2010; Wai, Lubinski, & Benbow, 2009). Despite significant progress in closing the gender gap, meaningful sex differences in mathematics and science achievement persist, at least for students in the USA (McGraw, Lubienski, & Strutchens, 2006; Reilly, Neumann, & Andrews, 2015). This is an active area of research, given the underrepresentation of women in science, technology, engineering and mathematics (collectively referred to as STEM) fields (National Science Foundation, 2011). Furthermore, international assessments of student achievement such as the OECD's Programme for International Student Assessment (PISA) also find sex differences in mathematics and science for some, but not for all, nations (Else-Quest, Hyde, & Linn, 2010; Guiso, Monte, Sapienza, & Zingales, 2008; Reilly, 2012). Secondly, verbal ability and language competence are essential life skills required for full participation in society and the workforce. Both within the United States, and cross-culturally, males consistently score significantly lower than females on tests of reading and writing (Guiso et al., 2008; Klecker, 2006; Lynn & Mikk, 2009; Reilly, 2012). Some researchers have speculated that this contributes to the growing trend across most Western nations of fewer men than women entering and completing tertiary education (Alon & Gelbgiser, 2011; Buchmann & DiPrete, 2006). Thirdly, both spatial and verbal abilities are specific cognitive abilities that are frequently investigated by sex researchers, and emerge as distinct separate factors of intelligence (Johnson & Bouchard, 2007).

1. Theoretical perspectives on sex-typed cognitive abilities

When sex differences are observed by researchers, this raises questions regarding their *origins* (Wood & Eagly, 2000). Early research into sex differences in cognitive abilities focused primarily on biologically-based explanations, including the contribution of hormones (Auyeung et al., 2009; Hines, 1990; Kimura & Hampson, 1994) and anatomical structures such as the corpus callosum (Hines, Chiu, McAdams, Bentler, & Lipcamon, 1992). One argument supporting such a view is the observation of *greater male variability* (Feingold, 1992; Machin & Pekkarinen, 2008), leading to exaggerated sex differences at the extreme tails of the ability distribution. While sex differences in the extremely gifted is an important topic in its own right, as they

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related to a relatively small percentage of the population, the majority of sex difference research is concerned with mean sex differences between males and females as a group. Empirical studies into the effect of hormones on cognition find mixed support (cf. Halari et al., 2005; Kimura & Hampson, 1994), and that they explain only a small percentage of variance. In recent decades explanations have broadened to incorporate sociocultural factors, such as differences between boys' and girls' early socialization experiences (Lytton & Romney, 1991), differential parental expectations for sons and daughters (Eccles, Jacobs, & Harold, 1990; Furnham, Reeves, & Budhani, 2002), gender stereotypes (Archer, 1992; Shapiro & Williams, 2012), and cultural beliefs (Guiso et al., 2008; Reilly, 2012). Most researchers now accept that sex differences are influenced by a network of biological and sociocultural factors rather than any single factor (Ceci, Williams, & Barnett, 2009; Nisbett et al., 2012; Wood & Eagly, 2012).

2. Sex role mediation of cognitive abilities

While it is difficult to disentangle nature from nurture, a commonality that is shared by both is that they contribute towards the development of an individual's *sex-role identity* or the degree to which an individual embodies stereotypically masculine and feminine personality traits, behaviors, and interests (Bem, 1981b; Spence & Buckner, 2000). Though boys and girls as two distinct groups will differ in their early socialization experiences (Lytton & Romney, 1991; Martin & Ruble, 2004), there is considerable individual variation within each gender group in the degree to which a person acquires sex-typed traits. While some children become rigidly sex-typed, others incorporate elements of both masculinity and femininity into their persona (Wood & Eagly, 2015). Highly sex-typed individuals are motivated to keep their behavior and self-concept consistent with traditional gender norms (Bem & Lenney, 1976; Martin & Ruble, 2004), including the sex-typing of specific skills, interests, and cognitive abilities.

Nash (1979) proposed the *sex-role mediation hypothesis* as one such explanation for the origins of sex differences in specific cognitive abilities. Nash (1979, p. 263) wrote "For some people, cultural myths are translated into personality beliefs which can affect cognitive functioning in sex-typed intellectual domains". This argument was based on earlier work by Sherman (1967) into differential learning and practice experiences of boys and girls. Under the sex-role mediation hypothesis, masculine identification promotes the development of spatial reasoning and mathematics, while feminine identification promotes verbal ability and language aptitude (see Fig. 1). Essentially, the sex-role mediation hypothesis proposes that group differences in cognitive abilities emerge as a result of individual differences in sex-role identification (Durkin, 1987).

There is evidence to support sex-role mediation, at least for the development of spatial ability. Reilly and Neumann (2013) conducted a meta-analysis of the association between masculinity and mental rotation (the most commonly used measure of spatial ability), finding a robust association for both males and females. However, it is unclear whether such an association generalizes to other types of spatial ability such as spatial perception and visualization. An earlier review by Signorella and Jamison (1986) found an association with these types of measures, but it is unclear whether a similar result would be found in modern samples. Furthermore, few studies have investigated the second aspect of Nash's sex-role mediation hypothesis, namely that feminine identification promotes the development of reading and language skills. Indeed, Signorella and Jamison noted that there was "a paucity of studies" (p. 219) that provide a test of sex-role mediation with language tasks.

3. The present study

The aim of the present study is to test the sex-role mediation hypothesis across a broader range of spatial and verbal tasks than previously used by researchers. There have also been considerable changes in the roles of men and women with the passage of time, so it is arguable whether historical conceptualizations of masculinity and femininity still apply (Auster & Ohm, 2000; Hoffman & Borders, 2001). Furthermore, some researchers have claimed that the magnitude of sex differences is diminishing in response to these social changes (Priess & Hyde, 2010). However, implicit gender stereotypes about sex-typing of cognitive tasks as being either masculine or feminine remain strong (Martin & Ruble, 2004; Nosek, Banaji, & Greenwald, 2002), as do beliefs about cognitive sex differences (Halpern, Straight, et al., 2011). We set out to determine whether previous experimental studies finding evidence of sex-role mediation (e.g. Hamilton, 1995) would be replicated when recruiting from a modern sample of young adults.

Linn and Petersen (1985) categorized tests of spatial ability as falling into one of three domains: mental rotation, spatial perception, and spatial visualization. The largest sex differences are found in mental rotation, while spatial perception also shows appreciably large sex differences (Voyer et al., 1995). However, the skill of spatial visualization shows relatively small sex differences which are sometimes not statistically significant, and so is less seldom included in a battery of cognitive measures. We selected measures from all three spatial domains (rotation, perception and visualization) so as to provide good content validity of spatial reasoning. We also employed a second test of mental rotation using two dimensional objects as stimuli, as most mental rotation tasks employ three dimensional objects at a cost of increased task difficulty.

The range of tasks available for measuring verbal ability is broad and less neatly defined than for spatial ability (Hyde & Linn, 1988). Sex differences in verbal fluency are apparent early in development (Halpern & Lamay, 2000), and are moderate in size (Hines, 1990). We selected phonological verbal fluency for this purpose as it is a widely used cognitive measure in psychological research. We also included a synonym generation task, which requires participants to generate words that are similar in meaning (associational fluency). Sex difference researchers have also found large sex differences in reading comprehension and writing (Lynn, 1992), and so we also included a measure of reading and grammatical skills known to produce moderately large sex differences (Stanley, Benbow, Brody, Dauber, & Lupkowski, 1992).

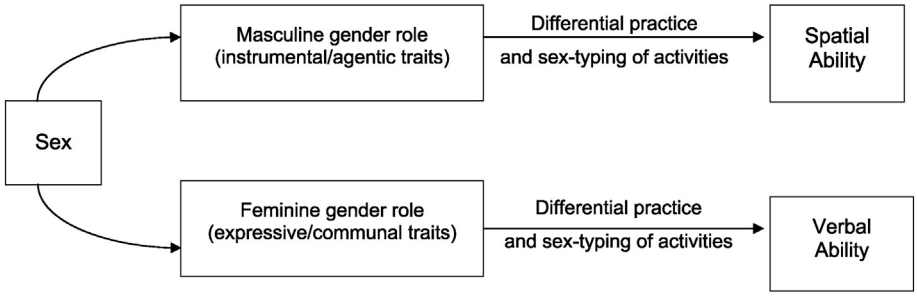

Fig. 1. Nash's (1979) *sex-role mediation* theory of cognitive abilities.