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Biosocial factors, sexual orientation and neurocognitive functioning

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Summary It has been proposed that sexual orientation related differences in cognitive performance are either due to the actions of prenatal factors early in development or the influence of gender role learning. This study examined the performance of 240 healthy, right-handed heterosexual and homosexual males and females ($N = 60$ per group) on a battery of cognitive tasks comprising mental rotation, judgement of line orientation (JLO), verbal fluency, perceptual speed and object location memory. Measures were also taken of the psychological gender, birth order, sibling sex composition and the 2nd to 4th finger length ratios of the right and left hands. A series of stepwise regression analyses revealed that sex and sexual orientation were the strongest predictors of cognitive performance, with IQ also contributing considerable variance. Psychological gender (M/F scores) added a small, but significant, amount of variance to mental rotation and perceptual speed scores in addition to these main factors, but prenatal hormone related indices, such as 2nd to 4th finger ratios, birth order and sibling sex composition added no independent predictive power. These findings are discussed in relation to biosocial influences on cognitive differences between heterosexuals and homosexuals.

1. Introduction

Sex differences in certain cognitive functions are well documented. Males, an average, outperform females in the tests of mental rotation, spatial perception, mathematical problem-solving and spatial navigation, while females do better than males in the tests of phonological and semantic fluency, perceptual speed, and memory for object locations (e.g. Voyer et al., 1995; Herlitz et al., 1997; Astur et al., 1998; Kimura, 1999; Acevedo et al., 2000; Collaer and Nelson, 2002). Often, these differences are task-specific. For example, although males excel at mathematical problem-solving, females do better in tests involving serial computation (Kimura, 1999). In the domain of spatial memory, the two sexes diverge in their performance as a function of the type of process examined; males performing better at navigation and place learning and females at memory for the spatial location of objects (McBurney et al., 1997; Astur et al., 1998).

It is therefore unsurprising that, the issue has been complicated further by the existence of

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cognitive differences between heterosexual and homosexual males and females, these within-sex variations contributing to the often elusive nature of ''normative'' sex differences (Sanders et al., 2002). Several studies have reported female-typical performance by homosexual males on mental rotations, spatial perception (for example on the water level test: Thomas et al., 1973), single item measures of letter and category fluency, verbal and performance IQ scores of the WAIS and on lexical decision-making (Sanders and Ross-Field, 1986, 1987; Gladue et al., 1990; McCormick and Witelson, 1991; Wegesin, 1998). The most replicable difference appears to be on mental rotations (Wegesin, 1998; Neave et al., 1999). However, one study failed to find any sexual orientation related cognitive differences (Gladue and Bailey, 1995). Most of these studies report no differences between heterosexual and homosexual females. In the most recent investigations in this area, using a large sample, homosexual males have been found to show female-typical performance in mental rotation, judgement of line orientation (JLO), phonological and semantic fluency, digit-symbol substitution and object location memory (Rahman and Wilson, 2003a; Rahman et al., 2003a, b; Rahman et al., in press). Rahman et al. (2003b) also reported that homosexual females scored in male-typical directions on phonological and semantic fluency measures. They did not differ from heterosexual females in any other cognitive task. The effect sizes for these sexual orientation related differences were usually modest to large effects by standard definitions (Cohen's $d = 0.5$–1.2), often comparable to the heterosexual sex difference. These findings support the ''sexual orientation model'' which proposes that sexual orientation exerts an influence just as powerful as sex per se on sexually dimorphic cognitive performance (Sanders and Ross-Field, 1987).

Although the existence of sexual orientation related cognitive differences may be robust, it is far from clear as to which factors are formative in these neurocognitive patterns. Empirical debate around the origins of sex differences in neurobehavioural measures polarises between those proposing gender role socialisation factors as important determinants versus those emphasising biological, primarily hormonal, factors.

Males and females differ in both these broad factors, as well as a myriad of other biological and experiential variables. Gender role socialisation theorists propose that internalised stereotypical notions about male and female personality from the social and cultural context, or from parental gender role reinforcement, lead to engagement in sex-differentiated activities and behaviour. These, in turn, are said to reinforce specific psychological mechanisms that ultimately form the basis for specific cognitive functions which themselves show sex differences, usually by adulthood (Caplan and Caplan, 1994). Although many studies show associations between measures of psychological gender, often ascribed to gender role socialisation, and spatial ability, such as mental rotation, the effect of sex is often greater than the effects of psychological gender (e.g. Jamison and Signorella, 1987; Hamilton, 1995; Parameswaran, 1995; Weekes et al., 1995; Saucier et al., 2002).

Males and females also differ in their prenatal exposure to sex steroids (i.e. androgens, estrogens and progestins) and these hormones, probably in concert with other biological and non-biological factors, almost certainly play a role in the development of cognitive and other behavioural sex differences (Collaer and Hines, 1995; Hines, 2000). Experimental manipulations in animals have demonstrated clear sex steroid effects on cognitive functions such as spatial memory (Williams et al., 1990). In humans, exposure to elevated androgens in utero (most obviously in the condition of congenital adrenal hyperplasia in females) appears likely to influence childhood play behaviour, sexual preferences, propensity towards aggression, but the evidence is weaker and less consistent for prenatal hormone effects on sexually dimorphic cognitive functions in these populations (reviewed in Hines, 2000). Studies of the activational effects of serum and saliva levels of sex hormones show either positive, negative, null or curvilinear effects on cognition, i.e., they are inconsistent (e.g. Silverman et al., 1999), whilst exogenously administered hormones, such as those given to transsexuals, lead to an improvement in male-typical spatial functions, such as mental rotation ability, and occasionally in female favouring functions, such as verbal fluency, although this is not consistently demonstrated at follow-up (Van Goozen et al., 1994, 1995; Miles et al., 1998; Slabbekoorn et al., 1999). Studies of menstrual cycle effects show that both estrogens and testosterone modulate sex-dimorphic (but not sex-neutral) cognitive performance and cerebral asymmetries (Hausmann et al., 2000; Maki et al., 2002).

Recently, interest has turned to non-invasive somatic markers often ascribed to the effects of prenatal androgens. One focus of the present investigation is on the 2nd to 4th finger length ratio (2D:4D), often ascribed to prenatal androgen influences. In fact, the evidence for such a link is reasonably strong. The 2D:4D ratio is sexually dimorphic, with men showing reduced ratios and women greater (Manning et al., 1998, 2000). Stu-