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Review article

Sexual orientation and neurocognitive ability: A meta-analysis in men and women

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ABSTRACT

The cross-sex-shift hypothesis predicts that homosexual men and women will be similar in certain neurobehavioral traits to their opposite-sex counterparts. Accordingly, it predicts that homosexual men should perform in the direction of heterosexual women, and homosexual women in the direction of heterosexual men, on neurocognitive tests that show normative sex differences. We conducted a meta-analysis on the relationship between sexual orientation and cognitive performance, and tested the effects of potential moderating variables separately by sex. A total of 106 samples and 254,231 participants were included. The meta-analysis revealed that homosexual men performed like heterosexual women in both male-favouring (e.g., spatial cognition) and female-favouring (e.g., verbal fluency) cognitive tests, while homosexual women performed like heterosexual men only in male-favouring tests. The magnitude of the sexual orientation difference varied across cognitive domains (larger for spatial abilities). It was also larger in studies comparing exclusive heterosexuals with exclusive homosexuals compared to studies comparing exclusive heterosexuals with non-exclusive homosexuals for both sexes. The results may narrow down potential sites for sexual orientation-related neural differences.

1. Introduction

Sex differences in cognitive abilities are well documented. Typically, men score higher than women, on average, on spatial tasks involving mental rotation of three-dimensional figures, spatial visualization (such as paper folding), disembedding (finding simple figures hidden in more complex forms), spatial perception (determining horizontal and vertical angles), maze navigation, spatial learning and navigation (including tests of way-finding in real-world settings as well as on computerized tests such as the Morris Water Maze), and targeting and intercepting objects. Women score higher than men, on average, on tests of phonetic and semantic fluency, verbal memory, object location memory, visual memory, facial emotion recognition, and some tests of social cognition (e.g., Coluccia and Louse, 2004; Hyde, 1981; Kimura, 2002; Voyer et al., 1995). The origins of these sex differences are disputed by scholars from across the biological sciences (including neuroscience), behavioural and social sciences (e.g., Fine, 2010; McCarthy and Konkle, 2005). However, there are likely multifactorial causes involved, such as differences in cerebral lateralization, psychosocial factors (e.g., gender socialization), and the influence of prenatal and circulating levels of sex hormones (Collaer and Hines, 1995).

Growing research shows that sexual orientation is also related to cognitive performance; most notably on tests that show normative sex differences. For example, studies of basic visuospatial abilities, spatial memory, and verbal fluency show that homosexual individuals appear shifted in the direction of the other sex (or "cross-sex shifted"). However, this pattern is task-specific and studies yield inconsistent results. Homosexual men have lower scores compared to heterosexual men on mental rotations and judgement of line orientation (and not significantly different from heterosexual women) in some studies (Collaer et al., 2007; McCormick and Witelson, 1991; Neave et al., 1999; Rahman and Wilson, 2003; Sanders and Ross-Field, 1986; Sanders and Wright, 1997; Wegesin, 1998). But one study found no differences in mental rotation and spatial perception between heterosexual and homosexual men after controlling for general intelligence (Gladue and Bailey, 1995). Studies also show that homosexual men have lower performance compared to heterosexual men in spatial navigation (e.g., Morris Water Maze tests) but better object location memory (and are no different to the performance of heterosexual women; Cánovas and Cimadevilla, 2011; Hassan and Rahman, 2007; Rahman and Koerting, 2008; Rahman et al., 2003a, 2003b). The magnitude of this difference appears smaller for spatial navigation than for object location memory. In the verbal domain, the picture is complex with homosexual men scoring higher than both heterosexual men and women in some domains (e.g., phonetic fluency) but performing better than heterosexual men (and no differently to heterosexual women) in

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others (e.g., semantic fluency; Rahman et al., 2003a, 2003b). Yet other studies do not find sexual orientation differences in verbal ability (Gladue et al., 1990).

The cognitive performance of homosexual women is generally female-typical, except in verbal fluency and possibly targeted throwing (Hall and Kimura, 1995; Rahman et al., 2003a, 2003b). However, one study reported that homosexual women were lower scoring than heterosexual women on a test of spatial perception (Gladue et al., 1990). Homosexual women are under-studied compared to homosexual men in this area. Sexual orientation differences in domains related to social cognition, such as facial emotion recognition, are also poorly studied or show no group differences (Rahman et al., 2004a) or cross-sex shifts in cognitive components whose meaning is not entirely clear (e.g., homosexual men and heterosexual women appear left-lateralized when inspecting female faces on a Chimeric Faces Test; Rahman and Yusuf, 2015).

Several theoretical and methodological moderator variables may partially account for the above inconsistencies. These include cognitive domain. The more robust sexual orientation differences appear on spatial tasks compared to verbal or other non-spatial tests. Age maybe an important factor because of known age-related cognitive decline and the fact that homosexual participants are often significantly older than heterosexuals in the studies, due perhaps to recruitment practices. Thus, potentially more robust sexual orientation differences may appear in studies in which homosexual participants are significantly older than heterosexual, or may be associated with age-related variance in certain cognitive outcomes (e.g., men tending to show greater age-decline in a range of cognitive functions compared to women; Maylor et al., 2007). Education level often serves as a proxy for general intelligence but is inconsistently measured across previous studies. Finally, the exclusivity of homosexuality may be important. Prior studies either use strict definitions of sexual orientation categories (comparing exclusive heterosexuals with exclusive homosexuals; e.g., Rahman et al., 2003a, 2003b; McCormick and Witelson, 1991), or compare exclusive heterosexuals with non-exclusive homosexual groups (including bisexuals or the broad category of “non-heterosexual” individuals; e.g., Collaer et al., 2007; van Anders and Hampson, 2005). The inclusion of bisexual individuals may potentially obfuscate the detection of sexual orientation cognitive differences at the ends of the sexual orientation spectrum, or their inclusion may reveal that the broader category of “non-heterosexual” show a mix of male-typical and female-typical cognitive profiles.

Thus far, the balance of evidence indicates that the cognitive profiles of homosexual men are cross-sex shifted in some domains. This does not appear to be the case in homosexual women. Theoretical accounts for these differences focus on prenatal androgens acting on developing brain mechanisms underlying sexuality and associated behavioural correlates (Collaer and Hines, 1995; Ellis and Ames, 1987). Prenatal sex hormones are predicted to organise both sexual orientation and cognitive ability in sex-atypical directions among homosexual men and women. The cognitive evidence among homosexual men offers some support for this. Further support comes from girls with androgen over-exposure in-utero (due to congenital adrenal hyperplasia) who show elevated non-heterosexual attractions and male-typical spatial performance (Hines et al., 2004; Mueller et al., 2008; Puts et al., 2008). Other mechanisms may involve learning and gender-related experiences. For example, greater time spent by men on visuo-spatial activities, like videogames, compared to women may be associated with greater sex differences in certain spatial tasks, while videogame training of both sexes has been reported to reduce the sex difference in mental rotation somewhat (Barnett et al., 1997; Feng et al., 2007; Lawton and Morrin, 1999).

Cross-sex shifts in brain structure and function may underlie the behavioural differences reported above. Heterosexual men and homosexual women show a greater rightward bias in cerebral asymmetry whereas cerebral volumes of each hemisphere are more symmetrical in heterosexual women and homosexual men. A cross-sex shift was also reported in the connections from the left and right amygdalae whereby homosexual men and heterosexual women had similar connections arising from the left amygdala while homosexual women and heterosexual men had similar connections arising from the right amygdala (Savic and Lindström, 2008). Homosexual men (in congruence with heterosexual women) also show stronger hypothalamic activation to smelling a male-specific odorous compound compared to heterosexual men (Savic et al., 2005). Homosexual women appear shifted in the direction of heterosexual men in response to a female odor (Berglund et al., 2006).

However, other neuroanatomical findings are difficult to interpret as cross-sex shifts. One study reported a larger isthmal region of the corpus callosum in homosexual compared to heterosexual men (Witelson et al., 2008). The absence of female comparison groups means we cannot know if this difference is cross-sex shifted. Another study reported that homosexual women (like heterosexual men) had less grey matter in the perirhinal cortex while heterosexual and homosexual men did not differ (Ponseti et al., 2007). This brain region is involved in spatial memory but given homosexual and heterosexual women do not differ in this ability, the significance of the finding is not clear. Homosexual men and women also appear similar to their same-sex heterosexual peers in their neural processing of visual erotic stimuli (Ponseti et al., 2006; Safron et al., 2007, 2017)

In sum, the extant literature on sexual orientation and cognition is mixed, especially in relation to cognitive domains (spatial versus non-spatial), highlighting the need for meta-analytic studies. Moreover, the results of this meta-analysis could narrow the potential sites of structural and functional neural differences between people of different sexual orientation for investigation by future researchers. We therefore undertook a meta-analysis of all published studies that examined sexual orientation differences in cognitive abilities in order to better identify sources of variation between studies and assess the strength of the predicted cross-sex shift. This includes the effects of potential moderating variables including cognitive performance type (male-favouring or female-favouring), cognitive domain (spatial, verbal and other), age, education level, and exclusively of homosexuality.

2. Method

2.1. Selection of studies

We used two search methods to identify eligible articles that published between January 1980 and February 2017. First, we searched the electronic databases PubMed, PsychInfo, Google Scholar, and ProQuest, for articles examining the association between cognitive performance and sexual orientation, using combinations of the following terms: (*visuo-spatial*, or *mental rotation*, or *spatial perception*, or *spatial visualization*, or *spatial orientation*, or *spatial learning*, or *verbal fluency*, or *perceptual speed*, or *object location memory*, or *judgment of line angle*, or *judgment of line position*, or *water level task*, or *spatial memory*, or *facial emotion*, or *spatial navigation*, or *functional cerebral asymmetry*, or *cognitive*) and (*sexual orientation*, or *homosexual,* or *heterosexual*, or *non-heterosexual*, or *gay*, or *lesbian*, or *straight*). Second, references were obtained using the articles obtained in the first method. In addition, two relevant unpublished raw datasets provided by the last author were also included. We also emailed authors directly where statistics were not available in some published articles.

To be included in this meta-analysis, articles needed to meet the following inclusion criteria: (a) their main or secondary objective was to investigate the association between cognitive performance and sexual orientation; (b) they reported sufficient data, including the values of *F*, *t*, mean and *SD* of cognitive performance separately for homosexual men, heterosexual men, homosexual women, and heterosexual women, or other statistics, to determine the effect size; (c) they provided the sample size separately for homosexual men, heterosexual