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Sexual orientation related differences in spatial memory

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Abstract

The purpose of this study was to investigate and extend previously reported sex differences in object location memory by comparing the performance of heterosexual and homosexual males and females. Subjects were 240 healthy, right-handed heterosexual and homosexual males and females. They were instructed to study 16 common, gender-neutral objects arranged randomly in an array and subsequently tested for object recall, object recognition and spatial location memory. Females recalled significantly more objects than males, although there were no group differences in object recognition. Decomposition of significant interactions between sex and sexual orientation on spatial location memory (controlling for differences in object recall, age and IQ) revealed that heterosexual females and homosexual males scored better than heterosexual males, and no different from each other. There were no differences between homosexual and heterosexual females. The findings suggest that homosexual males and heterosexual females encode, store and retrieve positional and relational information about spatial layouts similarly, pointing to within-sex variations in the neural architecture underlying spatial memory. (*JINS*, 2003, 9, 376–383.)

Keywords: Sex differences, Sexual orientation, Object location memory, Hippocampus

INTRODUCTION

Sex differences in spatial cognition are well documented. Typically, males excel on spatial tasks involving mental rotation of three-dimensional figures, spatial visualization (such as mental paper folding), disembedding (finding simple figures hidden in more complex forms), spatial perception (determining horizontal and vertical angles), maze navigation, and targeting and intercepting objects (e.g., Halpern, 1992; Kimura, 1999; Voyer et al., 1995). The origins of these differences are unknown, but has been variably attributed to differences in cerebral lateralization, sociocultural factors and (more recently) the influence of organizational and activational effects of gonadal hormones (Collaer & Hines, 1995; Maccoby & Jacklin, 1974; O'Connor et al., 2001). These spatial abilities appear to be strongly dependent on the integrity of the parietal cortex (Hamsher et al., 1992). Recently, neuroimaging studies have demonstrated that males have larger inferior parietal lobules and activate more extensive regions of the parietal cortex bilaterally during spatial perception tasks compared to females, possibly

underlying sex differences in performance (Frederiske et al., 1999; Gur et al., 2000). However, it has been suggested that sex researchers have treated spatial cognition as a rather broad concept in contrast to a cognitive neuropsychological viewpoint which aims to elucidate domain specific processes (Kolb & Whishaw, 1995; Lezak, 1995; Linn & Petersen, 1985). In fact, the largest of all sex differences appears to be restricted to processes which are strongly dependent on the parietal lobes, such as mental rotation (Cohen's $d = .9$) whereas differences for other types of spatial ability are modest at best (Kimura, 1999; Linn & Petersen, 1985).

By fractionating spatial cognition a more interesting pattern of sex differences has been revealed. In particular, sex differences in spatial memory have attracted growing interest (e.g., Postma et al., 1998). Spatial memory involves the ability to encode, store, and retrieve information regarding route navigation and object locations (Kessels et al., 2001). A large body of evidence from animal studies, and lesion and neuroimaging studies in humans confirms a major role for the hippocampal formation in spatial memory functioning (e.g., Abrahamas et al., 1997, 1999; Gron et al., 2000; Johnsrude et al., 1999; Nunn et al., 1999; Save et al., 1998). Additionally, the right hippocampus appears to be critical in processing of positional and relational information regarding the locations of objects in the form of an allocentric

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cognitive map (a frame of reference formed on the basis of information about the environment that is independent of the observer; Kessels et al., 2001; O'Keefe & Nadel, 1978). Hippocampal volumes relative to total cerebral size are also larger in females than in males, although there are no Side (right greater than left) \times Sex interactions (Filipek et al., 1994; Giedd et al., 1997).

Behaviorally, object location memory appears to be one form of spatial ability where females excel compared to males. In a series of pencil-and-paper studies by Eals and Silverman (Eals & Silverman, 1994; Silverman & Eals, 1992) females were shown to perform better than males on tasks where subjects were required to (1) identify items that had been added to a previously studied array of items, (2) indicate which items on a previously studied card had exchanged positions, and (3) recall the locations of common and uncommon objects in a room. Eals and Silverman (1994) refer to (1) as *object memory* and (2) and (3) as *object location memory*. In fact, of 19 administrations reported by these authors, only 7 (37%) failed to show sex differences favoring females, of which six were object memory rather than location tasks. Some have maintained that these differences could be due primarily to verbal strategies employed by females during object identity and recognition processing (Postma et al., 1998). However, two further studies looking at sex effects, which placed an emphasis on object location memory (aiming to reduce usage of nonspatial strategies), demonstrated a female advantage (Hill et al., 1995; McBurney et al., 1997).

Further sex differences in spatial memory have been demonstrated in the domain of place learning, this time in favor of males. Using a computer-generated "virtual maze," Mofat et al. (1998) showed that human males learned a route through the maze quicker, and made fewer errors (e.g., hitting dead-ends in the maze), than females. In a similar vein, Astur et al. (1998) employed a "virtual reality" version of the Morris water maze task in which human subjects were required to use spatial cues around the outside of a pool to navigate (or "swim") towards a hidden platform. They found that males consistently navigated to the hidden platform faster than females across a number of trials. Astur et al. (1998) noted the effect size of these differences as among the largest reported. A role for the hippocampus in place learning was demonstrated by Astur et al. (2002), who, using the same Morris water maze paradigm, reported that patients with unilateral hippocampal resections showed severe impairments in navigation compared to normal controls and patients with extrahippocampal resections.

Sex differences have been confused further with reports of within-sex variation in cognitive abilities demonstrating that homosexual males perform in female-typical directions on specific spatial tasks. In particular, homosexual males perform more poorly on mental rotation, spatial perception and targeting tasks but better on verbal fluency (a task that reliably produces a female advantage) compared to heterosexual males (Gladue et al., 1990; Hall & Kimura, 1995; McCormick & Witelson, 1991; Sanders & Ross-

Field, 1987). However, some reports failed to replicate these effects (Gladue & Bailey, 1995; Tuttle & Pillard, 1991). More recent investigations confirm the sex-atypical differences for homosexual males (Neave et al., 1999a; Wegesin, 1998a). The few studies that have tested homosexual females show sex-typical performance on mental rotation, spatial perception and verbal fluency (that is, no different from heterosexual females), whereas a male-typical trend has been reported on targeting tasks (e.g., Hall & Kimura, 1995). However, these sexual orientation studies comprised small samples (ranging from 13–32 subjects per group) and were poorly controlled for the extraneous effects of age and general intellectual ability, and replication is clearly needed on larger samples

As with normative sex differences in cognition, a number of factors have been forwarded to account for sexual orientation related differences. These have been generated primarily by the theory of neurohormonal sexual differentiation, in which the neurodevelopment of physiological and behavioral differences between males and females is proposed to be under the control of gonadal sex steroids. Homosexuals are considered to follow sex-atypical patterns of development in partner preferences and sexually dimorphic neuropsychological functioning (Ellis & Ames, 1987; LeVay, 1993). Homosexual males and females show robust sex-atypical shifts in retrospective and prospective childhood play interests and behavior and gender role orientation, and there is strong evidence to show similar shifts in cognitive functioning, neuroanatomical variation in hypothalamic and callosal regions, and neurophysiological activity in homosexual males (Alexander & Sufka, 1993; Bailey & Zucker, 1995; LeVay, 1991; Lippa, 2000; Sanders & Ross-Field, 1987; Reite et al., 1995; Scamvougeras et al., 1994). Genetic and prenatal hormonal factors are viewed as critical in the ontogenesis of these differences and for homosexual partner preferences (Hu et al., 1995; McFadden & Pasanen, 1998; Williams et al., 2000). Prenatal hormonal manipulations in animal models also affect aspects of spatial memory performance. Williams et al. (1990) demonstrated that castration of male rats (depriving them of early exposure to testosterone) caused them to produce more errors on a radial arm maze task, performing similarly to control female rats. Female rats treated with estradiol benzoate performed more like control male rats (i.e., made fewer errors than control females). Roof (1993) reported that the male advantage in radial and Morris water maze tasks was reversed under administration of exogenous testosterone soon after birth in rats (producing better performance in females and worse in males). These data suggest that the organizational influences of gonadal hormones on spatial behavior may be quadratic in males, that is, levels of testosterone above or below an optimum produce female-typical performance, whereas it is linear in females—high levels of testosterone and estrogens producing masculinization of performance.

In this study, the object location paradigm of Smith and Milner (1981, 1989) was employed to investigate possible

cross-sex shifts in the performance of homosexual males and females in comparison to heterosexual males and females. Based on the extant literature, we predicted that heterosexual females and homosexual males would perform better than heterosexual males on object location memory (and similarly to each other). Additionally, homosexual females were expected to perform comparably to heterosexual females (i.e., in a sex-typical manner). To our knowledge this is the first study to examine sexual orientation related effects in object location memory. Moreover, the Smith and Milner task has been shown to be sensitive to temporal lobe lesions and performance is dependant on the extent of hippocampal resection (Nunn et al., 1999; Smith & Milner, 1981, 1989). Hence, this is the first study to investigate sexual orientation related differences in cognitive functions dependent on the hippocampal regions. Elucidating within-sex variations in cognitive functions may provide clues to better understanding the neurodevelopment of sexual orientation (Allen & Gorski, 1992; Byne et al., 2001).

METHODS

Research Participants

Two hundred and forty healthy volunteers were recruited (60 heterosexual males, 60 homosexual males, 60 heterosexual females, and 60 homosexual females). They were screened to ensure no history of head injury, psychiatric or neurological illness, psychoactive medication or drug use. Heterosexual subjects were recruited from university sources, through newspaper advertisements and social networks. Homosexual subjects were also recruited from university gay and lesbian organizations, gay/lesbian press, and social networks. Thus, heterosexual and homosexual subjects were recruited from similar sources. All subjects came from within the London and Greater London areas and Southeast regions of England. Sexual orientation was assessed using a modified Kinsey scale (Coleman, 1987). Subjects were asked to respond to a question about self-identification, sexual/romantic attraction, sexual/romantic fantasies and sexual behavior on a 7-point scale, ranging from zero (*exclusively heterosexual*) to 6 (*exclusively homosexual*). Those scoring 5 or 6 were classified as *homosexual*, those scoring zero and 1 classified as *heterosexual*. Subjects with intermediate (*bisexual*) scores were not included in the study. The groups did not differ in number of years spent in full time education since the age of 5, ethnicity (classified as *white vs. non-white*) or socioeconomic status (categorized according to the Standard Occupational Classification of the Office of Population Censuses and Surveys; HMSO, 1991). For the purposes of the present study, only right-handed subjects (those scoring +31 to +100 on the Edinburgh Handedness Inventory (EHI; Oldfield, 1971) were included. Those scoring +30 and below were excluded from the study. The groups did not differ in mean EHI scores. All subjects were aged between 18 and 40 years, but a two-way ANOVA revealed a significant effect of sex [$F(1,239) = 13.460, p = .000$] and

sexual orientation [$F(1,239) = 10.722, p = .001$] on age. The mean ages (*SD*) were as follows: heterosexual males, 29.91 (6.60); homosexual males, 32.08 (5.66); heterosexual females, 26.80 (5.87) and homosexual females, 29.61 (5.35). General intellectual ability was assessed using Raven's Standard Progressive Matrices test (SPM; Raven, 1958). A two-way ANOVA revealed a significant main effect of sexual orientation [$F(1,239) = 4.012, p = .046$]; homosexuals had mean SPM score of 45.19 (*SD* = 6.55) and heterosexuals had a mean score of 46.95 (7.05). Thus, age and IQ were entered as covariates in subsequent analyses.

Materials

The object location memory task was a modified version of one described by Smith and Milner (1981, 1989). We chose this paradigm because it provides a more sensitive measure of location memory than the tests of Eals and Silverman (1994) and McBurney et al. (1997). Performance on this task is also known to be associated with hippocampal integrity.

There were 16 test objects (*ball, picture frame, whistle, sharpener, key, car, padlock, candle, screwdriver, watch, shell, battery, cotton reel, plug, spoon, scissors*) arranged randomly on 50 × 50 cm board (with the constraint that there was no obvious relationship between neighboring objects). For the purposes of later measurement, the position of each object was lightly outlined in pencil on the board. Some have argued that the female advantage in aspects of object recall and location memory may be artifacts caused by a lack of control over certain aspects of object identity and presentation (Neave et al., 1999b). We attempted to control for such factors by including sex-neutral objects, reducing object distinctiveness (in terms of size and shape) and equating distances between objects. Two raters agreed upon these criteria.

Procedure

On entry to the testing room, the array of objects was covered. Subjects were seated facing the arrangement. They were not told this was a location memory test; instead they were told that the procedure tested their ability to estimate prices of the objects. Subjects were instructed to name each object and provide a corresponding price value. They were told to point to the object using their finger but not to touch the objects. The subjects were tested on this procedure using a practice object (a small toy figure). The array of test objects was then revealed and the subjects were instructed to proceed naming and pricing each object in any order. Subjects were prompted or slowed so that 10 s of visual inspection was spent per object. When all the objects were evaluated the array was hidden. Subjects were given no indication that there would be further testing. Following a delay of 30 min (established during piloting of this task and used by others; e.g., Neave et al., 2000), three retention tests were administered in the following order:

1. *Object recall*: Subjects were asked to write down the names of as many objects as they could remember within 60 s. The score was total number of items (out of 16) correctly recalled.
2. *Object recognition*: This comprised a written test in which the name of each target object was presented in combination with three distracter items (objects in the same semantic category as the target). Subjects were required to underline the target objects. They were allowed 60 s for this test and it was scored as the total number of target items (out of 16) selected.
3. *Spatial location memory*: Subjects were given a new background sheet of paper (the same size as the original board) and the 16 objects. They were then asked to place them in their original positions as far as they could remember. Subjects were allowed 2 min for this. Subjects were required to place *all* the objects in a location, as best they could recall. The location of each object was marked in pencil once the task had been completed for measurement. Absolute distances were measured (in mm) between the original location of each object (at the time of price estimation) and the location in which it was subsequently placed (the method favored by Smith and Milner (1981)—by superimposing the sheet of paper and board in the same orientation and drawing straight line distances between the centers of each object). Measurements were then averaged across all objects, providing a mean absolute displacement score for each subject. Smith and Milner had used a second measure, relative spatial recall, but this yielded the same result as absolute displacement, and thus it was decided to use only the absolute measure. The absolute measure was also favored by Postma et al. (1998) in recent studies on sex differences, using a computerized version of the object location task that is more sensitive than measures used in the earlier studies of Eals and Silverman. Debriefing revealed that all subjects genuinely thought the procedure was a price estimation test. All subjects also reported that they did not intentionally remember the locations of objects.

Subjects gave informed written consent for testing. They were remunerated for their time. The Ethics (Research) Com-

mittee of the Institute of Psychiatry and Maudsley Hospital, London granted ethical approval.

Statistical Analyses

To determine whether the data were normally distributed, box plots were computed for each variable. Group differences in the three spatial memory measures, object recall, object recognition and spatial location memory were examined using the General Linear Model (GLM) factorial (Sex \times Sexual Orientation) analysis of covariance (ANCOVA) with age and IQ as covariates, using the Statistical Package for the Social Sciences (SPSS) Version 8.0. Decomposition of significant interactions involved a series of *t* tests. As there were four *post-hoc* comparisons we used a Bonferroni adjusted alpha level of .01, all other alphas were set at .05.

RESULTS

Object Recall and Recognition

Analysis of object recall revealed a significant main effect of sex [$F(1,239) = 6.977, p = .009$] with females recalling more objects than males overall, but no significant effect of sexual orientation [$F(1,239) = 1.783, p = .183$] or an interaction [$F(1,239) = .432, p = .512$; see Table 1]. IQ was a significant covariate in this model [$F(1,239) = 9.289, p = .003$] but age was not [$F(1,239) = .643, p = .423$]. There were no significant main effects of sex [$F(1,239) = .733, p = .393$], sexual orientation ($F(1,239) = 2.997, p = .085$) or their interaction [$F(1,239) = 3.052, p = .082$] on object recognition scores.

Spatial Location Memory

A factorial ANCOVA (with age and IQ as covariates) was applied to spatial location memory scores. There were no significant main effects of sex [$F(1,239) = 3.481, p = .063$] or sexual orientation [$F(1,239) = 3.166, p = .076$]; but there was a highly significant interaction between Sex \times Sexual Orientation [$F(1,239) = 22.612, p = .000$]. There

Table 1. Unadjusted (*SD*) and adjusted means for object recall, object recognition, and spatial location memory*

Group	Object recall			Object recognition			Spatial location memory**		
	Unadjusted		Adjusted	Unadjusted		Adjusted	Unadjusted		Adjusted
	<i>M</i>	(<i>SD</i>)	<i>M</i> _{adj}	<i>M</i>	(<i>SD</i>)	<i>M</i> _{adj}	<i>M</i>	(<i>SD</i>)	<i>M</i> _{adj}
Heterosexual males	8.28	(1.60)	8.23	14.75	(1.61)	14.70	73.72	(29.02)	73.58
Heterosexual females	8.91	(1.46)	8.92	14.91	(1.23)	14.87	51.83	(23.18)	52.72
Homosexual males	8.06	(1.56)	8.08	15.30	(1.23)	15.36	51.97	(26.29)	51.14
Homosexual females	8.48	(1.74)	8.50	14.85	(1.78)	14.87	61.22	(21.40)	61.29

*Adjusted for covariates age and IQ.

**Mean error scores.

were no significant effects of age [$F(1,239) = .000, p = .996$] and IQ [$F(1,239) = .334, p = .564$] as covariates. Decomposition of the interaction revealed that heterosexual females performed better than heterosexual males [$t(118) = 4.564, p = .000$], whereas homosexual males also outperformed heterosexual males [$t(118) = 4.301, p = .000$] and were no different from heterosexual females [$t(118) = .031, p = .975$]. By our stringent alpha level for *post-hoc* comparisons, the difference between homosexual and heterosexual females was not significant [$t(118) = -2.306, p = .023$], although homosexual females showed a trend in the direction of heterosexual males (Table 1).

A second ANCOVA model was conducted with the object recall as an additional covariate. Object recall was covaried in an attempt to control for possible verbal mediation of spatial location recall and because this measure differed by group. Although this adjusted model produced a significant main effect of sexual orientation [$F(1,239) = 4.103, p = .044$], homosexuals achieving better (lower) displacement scores than heterosexuals overall, the remaining results were no different from the previous model. There was no main effect of sex, but the interaction was significant [$F(1,239) = 22.056, p = .000$]. *Post-hoc* tests showed that heterosexual females performed better than heterosexual males [$t(118) = 4.564, p = .000$], whereas homosexual males also outperformed heterosexual males [$t(118) = 4.301, p = .000$] and were no different from heterosexual females [$t(118) = -.031, p = .975$]. The difference between homosexual and heterosexual females remained nonsignificant at the adjusted alpha level [$t(118) = -2.306, p = .023$]. Age and IQ remained nonsignificant as covariates [$F(1,239) = .018, p = .893$] but object recall was significant in this model [$F(1,239) = 6.163, p = .014$].

DISCUSSION

The aim of the present study was to investigate performance differences in a test of object location memory between homosexual and heterosexual males and females. The results demonstrate significant sexual orientation related effects on object location memory. Heterosexual females and homosexual males were found to perform better on object location memory than heterosexual men, whereas homosexual females did not perform differently to heterosexual females, confirming our predictions.

The findings are consistent with previous studies reporting a female advantage in object location memory (e.g., Eals & Silverman, 1994; Hill et al., 1995; James & Kimura, 1997; McBurney et al., 1997; Silverman & Eals, 1992) compared to other forms of spatial cognition where a male advantage is evident (such as mental rotation; Voyer et al., 1995). In contrast to Eals and Silverman (1994) and Silverman and Eals (1992), who employed nonstandardized versions of object memory and object location tests, we demonstrated some support for McBurney et al.'s (1997) assertion that any female advantage is for recall of spatial locations *per se* rather than memory for object identity using

a standard neuropsychological paradigm. However, we have shown that the proposed sex difference is strongly dependent on male sexual orientation, such that it is heterosexual males who demonstrate the poorest recall of spatial locations: heterosexual females and homosexual males show the greatest recall, and homosexual and heterosexual females do not differ. The results also indicated that females recalled the names of more objects than males (which is most likely related to greater usage of verbal processing by females). An attempt was made to control verbal mediation of spatial location processing by covarying object recall scores; significant group differences remained after this was adjusted. The Smith and Milner task primarily employs incidental learning, reducing the likelihood that subjects would develop nonspatial strategies to aid memory. Regarding visual object recognition, the presence of a ceiling effect precludes the conclusion of an absence of a sex difference on this test.

The data reported here are the first to demonstrate sex-related effects in performance on the Smith and Milner (1981, 1989) paradigm. Object location memory on this task has been shown to be sensitive to hippocampal lesions (Nunn et al., 1999; Smith & Milner, 1981, 1989) hence the female advantage on this measure suggest sex-related differences in allocentric spatial memory dependent on hippocampal function. Supporting this possibility, sex differences in the size of the hippocampus have been previously reported; females possessing larger hippocampal volumes than males (Filipek et al., 1994; Giedd et al., 1997). However, in a recent functional MRI study, Gron et al. (2000) found that males activated the hippocampal and parahippocampal regions of the brain during a spatial memory task employing maze navigation, whereas females failed to activate hippocampal regions, relying instead on right parietal and prefrontal regions. Thus male-favoring maze navigation tasks are also dependent on the hippocampal formation. In addition, it should be noted that the Smith and Milner task does not necessarily discourage the use of nonhippocampal egocentric processing strategies as it comprises a viewer-dependent frame of reference (subjects are seated in front of the array of objects and do not switch position).

The present study is the first to demonstrate that homosexual males show a clear shift in performance on spatial location memory in a female-typical direction. These findings add to growing evidence for cross-sex shifts in the neuropsychological profiles of homosexual males as predicted by the theory of neurohormonal differentiation (Ellis & Ames, 1987). They have parallels to prior work demonstrating female-typical performance by homosexual males in other cognitive functions, such as poorer scores on mental rotation and improved verbal abilities (Gladue et al, 1990; Hall & Kimura, 1995; McCormick & Witelson, 1991; Neave et al., 1999a; Sanders & Ross-Field, 1987; Wegesin, 1998a). They also augment findings that homosexual females do not show sex-atypical cognitive functions comparable to homosexual men. In the present study, homosexual and heterosexual females did not significantly differ, although les-

bians tended in the direction of a more male-typical pattern. Wegesin (1998a) reported nonsignificant trends by homosexual females towards male-typical directions in mental rotation and a lexical-decision/semantic-monitoring task. However, the majority of studies do not report such trends, instead reporting identical performance of homosexual and heterosexual females (e.g., Gladue et al., 1990; Gladue & Bailey, 1995; Tuttle & Pillard, 1991).

Overall, these data point to the need to control for sexual orientation in neuropsychological investigations where sex is considered an important between-groups variable. Furthermore, combining our findings with those of prior work suggest a dissociation in spatial cognition by sexual orientation. That is, for spatial functions that are strongly dependent on the parietal lobes (such as mental rotation), heterosexual females and homosexual males show a decrement in performance. For those tasks that are hippocampally based (such as object location memory) this effect is reversed: heterosexual females and homosexual males perform better. Such dissociation is speculative. The present study did not employ comparable tasks on which males excel (such as place learning tasks). The use of such tasks would have provided further information on the patterning of sexual orientation effects on cognitive functions associated with the hippocampus.

A primary role for the hippocampal formation in spatial location memory has been demonstrated across a number of studies (see Kessels et al., 2001, for a meta-analysis). If the established neural basis for spatial location memory is considered in relation to the results of the present investigation, functional differences in the hippocampal regions of homosexual males compared to heterosexual males seem probable. Neuroimaging studies may clarify this in the future. Nonetheless, support for a neural basis underlying sexual orientation related neurocognitive differences is already present. Reite et al. (1995) found more symmetric auditory source locations using magnetoencephalography (MEG) in homosexual compared to heterosexual men, a pattern more typical of women, which may reflect variations in the temporal regions between homosexual and heterosexual males. Alexander and Sufka (1993) demonstrated that patterns of EEG alpha activity during verbal and spatial tasks in homosexual males resembled those of heterosexual females, both differing from heterosexual males. Finally, Wegesin (1998b) reported that slow wave activity from ERP recordings during a mental rotation task were similar for homosexual males and heterosexual females, whereas homosexual females showed a nonsignificant trend in the male-typical direction.

Since the spatial location memory performance of homosexual males is consistent with previously found sex-atypical differences in other cognitive abilities, brain structure and functioning, and somatic differences between heterosexuals and homosexuals prenatal factors may be one possible explanation for these differences. However the involvement of cultural factors, such as gender-role socialization, has not been excluded.

In short, our findings reinforce the hypothesis that sexual orientation has differential effects on specific spatial functions and that within-sex effects need to be carefully considered in future investigations. The cross-sex shift in partner preference of homosexuals is apparently accompanied by marked shifts in neurocognitive performance.

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