RESEARCH ARTICLE

Excess of counterclockwise scalp hair-whorl rotation in homosexual men

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Abstract

While most men prefer women as their sexual partners, some are bisexual and others are homosexuals. It has been debated for a long time whether a person's sexual preference is innate, learned, or due to a combination of both causes. It was recently discovered that the human right-versus-left-hand use preference and the direction of scalp hair-whorl rotation develop from a common genetic mechanism. Such a mechanism controls functional specialization of brain hemispheres. Whether the same mechanism specifying mental makeup influences sexual preference was determined here by comparing hair-whorl rotation in groups enriched with homosexual men with that in males at large. Only a minority of 8.2% ($n = 207$) unselected 'control' group of males had counterclockwise rotation. In contrast, all three samples enriched with homosexual men exhibited highly significant ($P < 0.0001$), 3.6-fold excess (29.8%, $n = 272$) counterclockwise rotation. These results suggest that sexual preference may be influenced in a significant proportion of homosexual men by a biological/genetic factor that also controls direction of hair-whorl rotation.

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Introduction

Factors determining variation in human sexual preference are unknown. Since sexual preference is considered to be a 'complex trait', both multiple genetic and environmental factors are thought to be involved. Most models for biological explanations of sexual orientation have focussed on genes and/or prenatal hormone environments influencing the neuronal circuitry on which sexual preference is presumably inscribed (Pollard 1996; Mustanski *et al.* 2002a, Bocklandt and Hamer 2003). Studies using families and twin methodologies have favoured genetic influences on sexual orientation (Pillard and Weinrich 1986; Bailey and Pillard 1991). However, relatively little effort has been devoted to identifying specific genes. Two molecular studies suggested a putative X-linked gene in the Xq28 region for male homosexuality (Hamer *et al.* 1993; Hu *et al.* 1995), but two follow-up studies failed to replicate this finding (Bailey *et al.* 1999; Rice *et al.* 1999). Thus far, neither family pedigree nor molecular research has provided compelling evidence for the nature and number of inherited factors affecting sexual preference. Furthermore, homosexuality concerns both 'gay' men and 'lesbian' women; it is difficult to determine whether the same factors confer homosexuality to men as well as to women. To avoid the compounding sex-specific effects, this study addresses the aetiology of sexual preference of gay men only. The goal is to determine to what extent, if any, genetics influences gay men's orientation by exploiting a newly discovered biological trait that is genetically determined and is also clearly associated with the specification of human hand preference, and by inference, with the development of functional asymmetry between the brain hemispheres (Klar 2003).

Many studies have investigated the relationship between handedness preference and homosexual behaviour. Some have suggested that homosexual men are more likely to be non-right-handed (NRH, i.e. left-handed or ambidextrous) to varying degrees in comparison with heterosexual men (Gotestam *et al.* 1992; Halpern and Cass 1994; Holtzen 1994; Lalumiere *et al.* 2000; Lippa 2003), while

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other studies (Satz *et al.* 1991; Bogaert and Blanchard 1996; Mustanski *et al.* 2002b) have not found a significant difference. Thus, the literature highlights inconsistencies regarding the relationship between hand preference and sexual orientation. Complicating the interpretation of this possible association, thus far the aetiology of hand preference also has been considered as a complex trait, and therefore thought to be influenced by a combination of genetic and nongenetic factors (Klar 2003). Thus, the finding of increased incidence of NRH in some studies does not necessarily support a genetic basis for gay men's homosexuality. A considerable amount of literature is available on the topic but studies lack consensus on the causes of the homosexual behaviour.

An interesting relationship of handedness with the orientation of scalp hair-whorl rotation developed on the top of a person's head was recently discovered (Klar 2003). Most individuals exhibit a single hair whorl that rotates clockwise (C, figure 1) or counterclockwise (CC). The hair-whorl study concluded that a single locus separates right-handers (RH) from NRH and that the locus also controls the direction of hair-whorl rotation. Individuals carrying the hypothesized dominant locus, termed *RGHT1* (for right-handed), are RH, presumably due to specification of language processing in the left hemisphere of the brain and its coupling to both development of dominant hand on the contralateral, right side and to development of C crown hair whorl. According to this 'random-recessive model', homozygous individuals with the nonfunctional, recessive *r* (for random) allele do develop these traits, but they are independently and randomly distributed to the left versus the right side of the person. Notably, this model also explained handedness discordance of monozygotic twins by genetics due to their *r/r* genotype.

Figure 1. The hair-whorl phenotype. The picture shows scalp hair whorl of an anonymous man selected from the general public showing clockwise orientation. By holding the picture in front of a mirror and looking at its image, the reader can appreciate the counterclockwise orientation.

Materials and methods

The data on the first and second samples were collected in September 2003, when by chance I happened to be vacationing at a beach where preponderance of gay men was fortuitously noticed. The subjects were considered to be homosexuals because of their public display of stereotypical interpersonal relationship deemed typical of homosexual men. This assessment was reinforced by the dearth of females and children on the beach. More importantly, after the first serendipitous observation of preponderance of gay men was made, I discovered that the Rehoboth Beach is a well-known gay men's vacation spot in the state of Delaware in the US. Conveniently, the gay men were highly concentrated in one area of the beach. Such considerations made it relatively easy to collect the data on groups of predominantly gay men with great confidence even though the subjects were not asked for their sexual preference. Data on the third sample of gay men were collected from the same beach a year later on 30 May 2004. As a control of men vacationing at a conventional beach, observations were made by visiting the beach at Atlantic City, New Jersey, on 12 June 2004. According to the National Institutes of Health guidelines for research with humans, informed consent from subjects is not required if the subjects are anonymous, and, additionally, if the observations are made discreetly and unobtrusively, without the subject's knowledge. This procedure was observed in the study.

Results

It should be noted that one is born with a specific hair-whorl rotation, its orientation does not change with ageing, and over 96% of individuals support a single hair whorl. Certainly the environment does not influence hair-whorl orientation, including the direction in which hair is combed. This realization provides one with an opportunity to unambiguously define the contribution, if any, of hair-whorl genetics to gay men's sexual preference by investigating the rotation of their hair whorls. Incidentally, since the hair whorl is found at the top ('crown') of the head and thereby it is difficult to observe one's own whorl, and the direction of orientation is seemingly an unimportant feature, most people are oblivious to the direction of their hair-whorl rotation. It takes two mirrors to observe one's own hair-whorl.

In this study I collected data on hair whorls of predominantly gay men relaxing on the beach in the town of Rehoboth Beach, USA, in the summer of 2003. The phenotype of hair-whorl orientation is easy to score by unobtrusively and discreetly observing the heads of subjects with short scalp hair (figure 1). Obviously, bald individuals, those with long hair, or those wearing a sun cap were not incorporated in the study. To avoid repeated counting of persons in each sample, I investigated the men by walking through the area only once. In the first sample with preponderance of gay men, 50 C and 24 CC (table 1) rotations were recorded. The preponderance of CC rotation, nearly one-third, in the first sample was vastly different from the value of 8.4% CC rotation found in the public at large, which included both males and females (Klar 2003). To make the study scientifically sound and to test reproducibility, it was thought essential to collect data for two other samples. Therefore, another visit to the same beach was made three weeks later. The third sample was collected one year later. Confirming the observation of excess of CC whorls in the first sample, the second and third samples were also enriched with individuals exhibiting CC orientation (table 1). Altogether, in a combined sample of 272 mostly gay men observed, 29.8% exhibited CC hair-whorl orientation (table 1). It is possible that a minority of the men included in this sample might not be gays, as they might have been visiting a friend; therefore, the figure of 29.8% CC should be taken as a minimum value for hair-whorl rotation of homosexual men.

Clearly the combined value of 29.8% CC orientation of three samples with preponderance of gay men should not be compared to the 8.4% reported previously for the combined sample of both males and females (Klar 2003). To avoid the possibility of recording gay men also present among men relaxing in other, ‘non-gay’ areas of the beach, data for an unselected, control group of males were not collected from the same beach. Rather, visits were made to local shopping malls, grocery stores, barber shops, gas stations, fast-food restaurants, gyms and three airports in the states of Maryland, New Hampshire and Massachusetts to collect data on males (both men and boys) randomly chosen from the general public, without enquiring about their sexual orientation; a minority of them are expected to be gays. Only 8.2% of the males in the control group exhibited the CC pattern (table 1), a percentage strikingly similar to the 8.4% value reported for the combined male and female population at large (Klar 2003).

It is formally possible that men with counterclockwise hair-whorl orientation prefer to visit the beach more often than those with the clockwise orientation for reasons unrelated to their sexual orientation. Therefore, as another control, data on men relaxing at another beach frequented by the general public, in Atlantic City in the nearby state of New Jersey, were collected. In this sample only 10.7% men showed counterclockwise orientation, a result not significantly different from the sample of males at large (table 1).

These results indicated that three samples enriched with homosexual men exhibited a remarkably increased proportion (3.6-fold) of CC hair-whorl rotation in comparison to males in the general public. Using the standard chi-square test, the c^2 value for each sample of gays differs from the value for control males with a very high level of significance ($P < 0.0001$, table 1). Although we cannot exclude the possibility that a few of the men were the same men present in more than one sample, the value for combined samples also differs from that for the control sample with a very high level of statistical significance ($c^2 = 174$, d.f. = 1, $P < 0.0001$, table 1).

Discussion

The increased incidence of CC hair-whorl rotation in gay men may be explained by one of two different genetic possibilities. One possibility is that some other unknown genetic factor(s), unrelated to the handedness trait, increases the proportion of CC rotation and also causes homosexuality. Although this is still an unresolved issue as stated above, several studies have reported a significantly increased proportion of left-handers among gay men (Gotestam *et al.* 1992; Halpern and Cass 1994; Holtzen 1994; Lalumiere *et al.* 2000; Lippa 2003). Also, it was recently suggested that handedness discordance of monozygotic twins results from random distribution of the trait to the left/right body axis owing to their *r/r* genotype according to the random-recessive model (Klar 2003). Similar to this random-distribution feature of the *r/r* handedness genetics, approximately 50% of monozy-

Table 1. Comparison of hair whorl rotation of males at large with men at a standard beach and with samples enriched in gay men.

Whorl orientation	Control males	Standard beach men control	Gay men samples 1	2	3	Total
Clockwise	190	108	50	70	71	191
Counterclockwise (CC)	17	13	24	27	30	81
Total sample size	207	121	74	97	101	272
% CC	8.2	10.7	32.4	27.8	29.7	29.8
Fold CC increase in gay men	1.0	1.3	3.9	3.4	3.6	3.6
c^2 value	–	0.98	58.7	49.1	65.7	172.1
P value	–	> 0.30	< 0.0001	< 0.0001	< 0.0001	< 0.0001

The numbers in the table are numbers of males observed in the indicated category.

gotic co-twin brothers of gay men are themselves gay (Bailey *et al.* 1993). This value for gay twins discordance is consistent with the thesis of association between sexual preference and handedness genetics, rather than to some other genetic factor also causing discordance in one-half of the co-twins. Therefore, perhaps the second possibility, more compatible with the data, is that hair-whorl genetics, and, by inference, handedness genetics, constitutes one of the predisposing factors influencing development of gay men's sexual preference. According to this possibility, one can calculate what fraction of all instances of male homosexuality should be attributed to hair-whorl/handedness genetics. Owing to random rotation in *r/r* individuals, 50% of them develop the C and 50% the CC pattern (Klar 2003). Accordingly, the value of at least 29.8% CC orientation in the enriched sample of gays suggests that at least 29.8% × 2 = 59.6% of gay men possess the *r/r* genetic constitution. Thus, the majority (59.6%) of gay men's sexual preference may be associated with the gene controlling hair-whorl orientation. As the present study only dealt with samples enriched in gay men, the value of CC rotation is likely to go up when data with self-reporting gay men are obtained in follow-up studies.

As noted above, most biological explanations of sexual orientation have considered multiple genes and/or prenatal hormone environments influencing neuronal circuitry. This study and others do not support a causal relationship between prenatal hormone level and sexual orientation, as men and women experiencing defects in hormone metabolism do not exhibit increased homosexual behaviour (Banks and Gartrell 1995). A different possibility invoking male homosexuality caused by maternal stress during pregnancy was already discounted by another study (Bailey 1989). Likewise, two new theories to explain sexual orientation of men, one proposing preconceptual programming of gametes by genomic imprinting (Pollard 1996), and another postulating genomic imprinting for regulating sex-specific genes (Bocklandt and Hamer 2003), are not easily applicable to 59.6% of men in these samples if their orientation results from the *r/r* genotype. This is not to say that all men with CC hair whorls, and only individuals with CC rotation, should become homosexuals. Rather, we suggest that their *r/r* genetic constitution predisposes (i.e. increases the chance) them to develop homosexual orientation, in comparison to those with C hair whorls. It should be noted that even in the samples of homosexual men reported here, the majority (70.2%) exhibited C hair whorls. This indicates an imperfect relationship between hair-whorl orientation and homosexuality, both of which occur at a low rate in the population. Consequently, the trait of hair-whorl rotation in itself is not a definitive indicator of a man's sexual preference.

Considering the hair-whorl/handedness genetic possibility further, how can a partial association between the traits be explained? The results presented here lend support to one among the several possibilities considered previously, specifically the one concerning development of cerebral laterality (McCormick *et al.* 1990; Lalumiere *et al.* 2000). Although the two hemispheres of the brain are, overall, mirror images of each other, morphological differences in certain areas do exist. More importantly, the two hemispheres perform very different cognitive functions. The so-called 'dominant' hemisphere processes language and hand-use motor functions, while the 'automatic' hemisphere handles spatial and other nonverbal functions. Moreover, which side acquires which cognitive function is related to one's hand preference, albeit with a complex correlation (Klar 2003). Clearly, functionally important morphological differences do exist in the two hemispheres of most RH men. But curiously, decreased or reversed cerebral asymmetry is found in NRH singletons and both members of discordant monozygotic twin pairs (Geschwind *et al.* 2002, and references therein). It therefore follows, from the increased incidence of the inferred *r/r* genotype of gays in the present study, that development of less asymmetric brain hemispheres, or reversed asymmetry, increases the chance of these men developing homosexual behaviour. As sexual orientation is a nonpathological behavioural phenomenon, by following the partial hair-whorl relationship presented here, it should be fruitful in future studies to compare possible differences of brain hemispheric lateralization among homosexual and heterosexual men.

But what does hair-whorl orientation have to do with the trait of sexual preference? As our scalp, brain and handedness traits derive from the ectoderm layer of embryonic cells, it was recently suggested that the *RGHT1* gene may have evolved in humans to control nonrandom distribution of these traits to our left/right body axis (Klar 2003). A challenge for future studies is to determine how brain laterality development could influence sexual preference. Perhaps a primary possibility to consider is that less asymmetric hemispheres may allow additional neuronal connections between different parts of the brain, thereby predisposing individuals to develop homosexuality, in contrast to the restricted possibilities allowed in the more common asymmetric hemispheric arrangement. This study implies that specification of male homosexuality developed as a non-pathological trait is likely not due to influence on development of sex organs; rather, the preference is dictated by the person's mental makeup owing to the naturally occurring genetic variation in brain laterality development. Other studies have examined genetic specification of sex-specific neuronal behaviour in model experimental organisms, and the observations support genetic aetiology. For example, *fruitless* gene mutant males of the fruit fly *Drosophila* prefer to sexually court other males rather than females (Hall 2002).

Last, as this initial study was limited to determining the rotation of hair whorls of gay men, and several previous studies were limited to handedness determination, in future it will be informative to ascertain both traits in the same sample of gay men to further scrutinize the association between these traits. Moreover, considering the important biological and sociopolitical implications of this initial study, once these results are publicly available one would not have to wait long for other investigators to scrutinize the conclusions of this study by independent and systematic studies involving self-reporting groups of gay men and samples from different geographical regions and populations. Also, it should be equally interesting to compare the proportions of C and CC hair-whorl orientations in lesbian women with those in females at large. Like the correlation between monozygotic co-twin brothers of gay men, ~ 50% of the twin sisters of lesbian women are themselves lesbian (Bailey *et al.* 1993). Therefore, an analogous contribution of hair-whorl/handedness genetics may be expected for women's homosexuality as well. An important implication of this study is that the trait of hair-whorl orientation, which does not change with age and cannot be altered, should replace handedness, which can be culturally changed, as a phenotypic marker for cerebral hemispheric lateralization. Therefore, similar relationship studies employing the easily discernible, definitive trait of hair-whorl rotation should be conducted for defining the role of brain hemispheric asymmetry in the aetiology of other human behavioural traits, such as autism, schizophrenia and bipolar disease, cognitive deficiency and speech dysfluency. Although some previous studies have hypothesized biological factors in the aetiology of homosexuality, while other studies have contradicted it, clear evidence has been lacking. This is the first study that shows a highly significant association of biologically specified CC hair-whorl rotation and homosexuality in a considerable proportion of men in samples enriched in gays. Thus, a genetic factor that controls the direction of hair-whorl rotation contributes to a significant proportion of gay man's sexual preference.

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