Behavioral Neuroscience
2009, Vol. 123, No. 2, 252–256

0735-7044/09/$12.00 DOI: 10.1037/a0014816

Hair Whorl Direction and Sexual Orientation in Human Males

Qazi Rahman
Queen Mary, University of London

Kenneth Clarke and Tirma Morera
University of East London

Hair whorl direction is a somatic feature that is organized early during neurodevelopment and unlikely to be influenced by social factors. This study aimed to replicate a widely reported association by A. J. S. Klar (2003) between counterclockwise hair whorl direction and homosexuality in men, using more objective methodology. The authors took digital photographs of parietal surface hair whorls from 100 heterosexual men and 100 homosexual men who were predominantly right-handed. These images were rated for clockwise and counterclockwise direction (for which no more than 1 hair whorl was present) by 2 raters unaware of sexual orientation. The authors found no significant difference between heterosexual and homosexual men in hair whorl direction, but the authors did replicate the fraternal birth order effect (more older brothers for homosexual men). Number of older sisters was positively correlated with counterclockwise hair whorls in heterosexual men. These data were discussed in relation to prenatal factors assumed to play a role in the neurodevelopment of male homosexuality.

Keywords: sexual orientation, hair whorls, fraternal birth order, prenatal androgen theory, developmental neurobiology

Understanding the development of human sexual orientation has become one of the most debated topics within the neuroscience and psychology of sexual behavior (Morris, Jordan, & Breedlove, 2004). Homosexuality constitutes a central variant in the human sexual phenotype, and thus studying its putative fetal origins may improve our understanding of neurodevelopmental mechanisms underlying behavioral sex differences in general (Rahman, 2005b). Besides genetic factors (Bailey, Dunne, & Martin, 2000; Långström, Rahman, Carlström, & Lichtenstein, in press; Mustanski et al., 2005), several somatic correlates of male and female homosexuality have been reported that may provide "biological windows" onto prenatal mechanisms thought to be involved in sexual orientation, such as prenatal androgen exposure and developmental instability. These correlates include relative finger length ratios, eyeblink startle reflex inhibition, and acoustic emissions produced by the cochlea, albeit with less than consistent results across studies (McFadden et al., 2005; Rahman, 2005a, 2005b). However, two reliable biological correlates for homosexuality in men are later fraternal birth order and elevated non-right handedness (Blanchard, 2004, 2008; Lalumiere, Blanchard, & Zucker, 2000).

The fraternal birth order (FBO) effect refers to the well-documented observation that homosexual men have a greater number of older brothers in relation to any other class of sibling in comparison with heterosexual men. It is thought to arise from a prenatal maternal immunization mechanism, whereby each successive male fetus elicits an ever-growing immune response from the mother toward male-linked antigens in neural tissue. This is thought to alter the typical sexual differentiation of brain regions relevant to sexual orientation (Blanchard, 2004, 2008). Elevated non-right handedness (that is, less than consistent right handedness, including mixed and left handedness) among homosexual men has been confirmed by one large meta-analysis, although some recent findings are conflicting (see Blanchard, 2008, for a review; cf. Lalumiere et al., 2000). Moreover, two studies suggest that the FBO effect is observed only among right-handed homosexual men (Blanchard, Cantor, Bogaert, Breedlove, & Ellis, 2006; Blanchard & Lippa, 2007). The neurodevelopmental mechanisms proposed for this relationship include prenatal androgen exposure, whereby differential levels of prenatal androgens between pre-heterosexual and pre-homosexual fetuses lead to variation in the neural organization of praxic and cognitive function (Rahman, 2005b), developmental instability in which elevated non-right handedness is considered a marker of perturbation in a developing neurobiological trajectory toward the species-typical pattern of heterosexuality (Lalumiere et al., 2000; Rahman, 2000a), and in light of the FBO data, possible maternal immune responses (Blanchard, 2008).

Direction of hair whorls (dichotomously classified as clockwise or counterclockwise in persons with only one observable hair whorl) has also been studied in relation to sexual orientation. This unusual biological marker may also have some bearing on handedness. Klar (2004) reported a 3.6-fold excess of counterclockwise whorls in 272 presumed homosexual men (29.8%) in comparison with 207 presumed heterosexual men (8.2%). Hair whorls were covertly observed, and subjectively recorded by the author, during visits made to a predominantly gay beach (this being the definition of homosexuality in the men observed) and several public spaces such as shopping malls (the definition of heterosexuality in the men observed). Previously, Klar reported a prevalence rate of counterclockwise hair whorls among covertly observed presumedly right-handed individuals ($n = 500$) of 8.4% in compari-

Qazi Rahman, Biological and Experimental Psychology Group, School of Biological Sciences, Queen Mary, University of London, London, United Kingdom; Kenneth Clarke and Tirma Morera, School of Psychology, University of East London, London, United Kingdom.

Correspondence concerning this article should be addressed to Qazi Rahman, Biological and Experimental Psychology Group, School of Biological Sciences, Queen Mary, University of London, Mile End Road, London, E1 4NS, United Kingdom. E-mail: q.rahman@qmul.ac.uk

son with 44.9% in directly assessed nonconsistent right handers ($n = 49$; Klar, 2003). Klar (2003) has forwarded a population genetic model in which a single gene is thought to affect both neural and somatic asymmetry, resulting in the pattern shown above. The model proposes that handedness and hair whorl direction in people with two recessive alleles of the gene are determined randomly and independently. In men, possessing at least one dominant allele would result in those individuals being right-handed, heterosexual, and having clockwise hair whorls, whereas possessing two recessive alleles would result in these phenotypes being expressed randomly and independently. However, several other studies have found that the base rate of counterclockwise hair whorl pattern ranges from 13% to 18.5% (Beaton & Mellor, 2007; Jansen et al., 2007). Jansen et al. (2007) is worthy of note here, because they had a large sample of 1212 individuals. Four studies have also reported no association between handedness and hair whorls (Annett, 1985; Collins, 1977; Jansen et al., 2007; Newman, 1934).

The substantial scientific and public interest in hair whorls following Klar's (2004) initial report may have arisen from the assumption that this structural marker of lateralization is not influenced by social factors because of its developmental origins in the same germinal cell layer as the central nervous system, the fetal ectoderm, between the 10th and 16th week of embryogenesis (Wunderlich & Heerema, 1975). Directional hair whorls are observed in newborn infants and do not change with age (Wunderlich & Heerema, 1975). Counterclockwise and multiple hair whorls are also associated with some neurodevelopmental disorders (Scott, Weinberg, Neiswanger, Brandon, & Marazita, 2005; Smith & Gong, 1974; Tirosh, Jaffe, & Dar, 1987). This evidence suggests a direct relationship between hair whorls and early brain development. Thus, to show a relationship between hair whorl direction and sexual orientation would strongly suggest that homosexuality in some men is determined by factors operating on the developing sexual brain prenatally.

It is clear that previous studies have not rigorously measured the variables of interest, relying instead on imprecise assessments of sexuality and subjective, nonindependent covert visual inspection of hair whorls. Here we wanted to objectively determine whether or not there was any evidence for an association between hair whorl patterns and sexual orientation. To do this, we used digital photographs of parietal scalp hair and standard questionnaire measures of sexuality, sibling sex composition, and handedness in predominantly right-handed heterosexual and homosexual men.

Method

Participants

A total of 100 heterosexual men and 100 homosexual men (ages 18–50 years) participated in the study. Both groups were recruited from the student population of the University of East London and from recognized gay areas of London (United Kingdom) also frequented by heterosexuals, including Soho and Shoreditch. We ensured that heterosexual men were recruited from the same sources as homosexual men to help reduce any possible ascertainment biases associated with one or the other group. While it is impossible to eliminate all such sampling biases in research with sexual minorities, our "targeted sampling" method ensures that there is internal validity to the comparisons being made because both populations were being sampled in a similar manner. In other words, any biases are made proportionate across the samples using this approach. Moreover, our methodology is unlikely to be influenced by such biases owing to the fact that we were measuring biodemographic variables that are not readily observable to the experimenters.

Participants were screened via a check-box questionnaire to exclude any lifetime history of psychiatric or neurological morbidity. The range of conditions included severe anxiety, recurrent depression, schizophrenia, manic depression, speech and language disorders, panic attacks, severe alcohol and drug dependence, severe oppositional behavior as a child, dissociation, any head injury, epilepsy, learning disability, any other developmental delay, and any other brain-related illness that they could recall. Participants were also excluded for any reported history of congenital or fetal developmental pathologies (however minor), obstetric complications during their gestation (from their recall of maternal reports) or, if they could not recall, were simply asked whether their mothers reported having carried them during a "normal pregnancy." Finally, anyone with a severe dermatological condition of the scalp was also excluded. The number of participants excluded because of these criteria was 11.

Participants' sexual orientation was assessed using one 7-point Kinsey scale of sexual feelings (fantasies and attractions) ranging from 0 (*exclusively heterosexual*) to 6 (*exclusively homosexual*; Kinsey, Pomeroy, & Martin, 1948) and one categorical item about self-identification as either "homosexual/gay," "heterosexual/straight," or "bisexual." Only participants who checked "homosexual/gay" or "heterosexual/straight" on the self-identification item and responded as 0 or 1 and 5 or 6 on the Kinsey item were included (i.e., were classified as *heterosexual* and *homosexual*). Demographic information was obtained regarding age, number of years spent in full-time education since the age of 5, and ethnicity classified as "White" (White European including Spanish/Anglo American/Australian/New Zealand/White South African), "Black" (African/Afro-Caribbean), "South Asian" (Indian/Pakistani/Bangladeshi/Sri Lankan), "East Asian" (Chinese/Japanese/Korean/Burmese/Vietnamese/Thai), "Hispanic" (South American/Mexican), or "Other" (e.g., Turkish).

Measures and Procedure

All participants provided written informed consent, and all procedures were approved by the University of East London Research Ethics Committee. Participants were not paid or compensated for taking part in this study.

Sibling sex composition. Participants were asked to list their number of older brothers, number of older sisters, number of younger brothers, and number of younger sisters. Only biological siblings carried by the participant's mother were to be listed, including those carried but not brought to term because of obstetric complications.

Handedness. Handedness was assessed using the Edinburgh Handedness Inventory (EHI; Oldfield, 1971) and required participants to demonstrate 10 unimanual tasks and to state the degree of preference for the hand used as either strong (2 points) or weak (1 point). A handedness laterality quotient was calculated by subtracting the score for the left hand from the score for the right hand,

dividing by the sum of both, and multiplying by 100. This provides a continuous measure of handedness from −100 (completely left handed) to +100 (completely right handed).

Hair whorls. Before completing any measure in the study (but after having provided written informed consent), we inspected each potential participant's parietal scalp region to see whether they possessed observable hair whorls. Thirteen men did not have such a whorl (because of baldness, very light hair color, thinning hair, or too much hair) and did not take part in the study. Otherwise, we took one digital photograph of each participant's observable hair whorl using a Canon Ixus digital camera under constant light conditions. Six participants had more than one hair whorl and were excluded from further analysis. Two raters unaware of sexual orientation, demographic information, and rationale behind the study rated the direction of hair whorls from each photograph as either clockwise or counterclockwise. Only hair whorl data for which there was complete (100%) agreement between the two raters was analyzed further (9 participants were excluded from further analysis on this basis). We applied this criterion because hair whorl direction provides truly dichotomous data (clockwise or counterclockwise).

Statistical Analysis

The main biodemographic variables (age, years in education, number and sex of siblings, and handedness scores) were analyzed using independent-samples *t* tests. Categorical variables, including number of counterclockwise hair whorls, were analyzed using chi-square tests. Point-biserial Pearson's correlations were used to explore interrelationships among variables. Finally, logistic regression was used to test whether the biodemographic and hair whorl measures predicted sexual orientation in men. We chose logistic regression because this multivariate technique may result in a different pattern of results in comparison with standard univariate analyses, but it also permits a direct comparison between the present data and previous studies using the same data analytical approach (Blanchard & Bogaert, 1996; Blanchard, Zucker, Siegelman, Dickey, & Klassen, 1998). The assumptions of regression were found to have been met on visual inspection of the residual plots that confirmed homoscedasticity, while inspection of the correlation matrix showed no evidence of multicollinearity (all rs $< .8$). All alphas were set at 0.05. All statistical analyses were performed using SPSS, Version 15.0.

Results

Participant Characteristics

There was no significant age difference between heterosexual and homosexual men, $t(198) = -.36$, $p > .10$, and no significant group difference in years spent in full-time education since the age of 5 years, $t(196) = 1.47$, $p > .10$ (see Table 1). For the analysis of ethnicity, there were too few cases (<5) in some cells to permit meaningful chi-square analysis, and therefore the data were collapsed into "White" and "non-White" categories. There were more non-White participants among heterosexuals than among homosexuals, $\chi^2(1) = 16.78$, $p < .01$. The frequencies for heterosexual men were 67 Whites and 33 non-Whites (4 Blacks, 2 South Asians, 10 East Asian, 1 Hispanic, and 16 Others), while for homosexual men there were 90 Whites and 10 non-Whites (0 Blacks, 3 South Asians, 2 East Asians, 0 Hispanics, and 5 Others).

Table 1
Means and Standard Deviations for Biodemographic Variables by Group

Variable	Heterosexual men		Homosexual men	
	M	*SD*	*M*	*SD*
Age (years)	31.18	7.87	31.60	8.49
Years of education	16.41	3.28	15.73	3.11
Number of older brothers	0.63	0.86	0.89	0.90
Number of older sisters	0.51	0.82	0.63	0.79
Number of younger brothers	0.37	0.66	0.25	0.47
Number of younger sisters	0.42	0.66	0.41	0.62
Handedness scores	67.63	54.65	76.43	49.03

Note. Handedness was measured with the Edinburgh Handedness Inventory (R. C. Oldfield, 1971).

Handedness. There was no significant difference in handedness scores between heterosexual and homosexual men, $t(198) = -1.19$, $p > .10$ (see Table 1). While the sample was predominantly right handed, we also collapsed the EHI data into "right-handers" (scoring between 0 and 100) and "left-handers" (scoring between −1 and −100). There were no significant differences between the number of heterosexual and homosexual men in those categories, $\chi^2(1) = .479$, $p > .10$ (12 out of 100 heterosexual men and 9 out of 100 homosexual men were classed as left handed).

Sibling sex composition. Table 1 shows that homosexual men had significantly more older brothers than did heterosexual men, $t(198) = -2.07$, $p = .039$. There were no significant group differences for number of older sisters, $t(198) = -1.04$, $p > .10$, number of younger sisters, $t(198) = 1.46$, $p > .10$, and number of younger brothers, $t(198) = .11$, $p > .10$. The sibling sex ratio for heterosexual men was 1.08 (100 brothers vs. 93 sisters) and was 1.10 for homosexual men (114 brothers and 104 sisters), consistent with general population norms of about 1.06 (James, 1987).

There were no significant correlations between EHI scores and any sibling sex composition measure for the whole sample or separately for each group (all ps $> .05$).

Hair whorl direction. The number of counterclockwise hair whorls did not differ significantly between heterosexual men (14/100, 14%) and homosexual men (18/100, 18%), $\chi^2(1) = .60$, $p > .10$. The prevalence of counterclockwise hair whorls for the whole sample was 16% (32/200).

The rate of counterclockwise hair whorls did not differ significantly between right-handers and left-handers when the sample was split according to their EHI scores, $\chi^2(1) = .05$, $p > .10$. We computed correlations between the number of counterclockwise hair whorls on the one hand, and EHI scores, number of older brothers, number of younger brothers, and number of younger sisters on the other. Thus, we do not present all possible pairwise correlations here. There were no significant correlations for the whole sample or each group separately (all ps $> .05$). However, there was a significant correlation between number of older sisters and number of counterclockwise hair whorls among heterosexual men only, $r(100) = .27$, $p > .01$ (see Table 2).

To test whether sibling sex composition measures, handedness scores, and number of counterclockwise hair whorls predicted

Table 2
Correlations Between Number of Counterclockwise Hair Whorls, Sibling Sex Composition, and Handedness Measures by Group

	Heterosexual men		Homosexual men	
Variable	*r*	*p*	*r*	*p*
Number of older brothers	−0.02	0.78	0.14	0.15
Number of older sisters	0.27	0.005	0.12	0.23
Number of younger brothers	−0.05	0.61	0.13	0.17
Number of younger sisters	−0.16	0.09	0.06	0.50
Handedness scores	−0.14	0.14	0.09	0.37

Note. Handedness was measured with the Edinburgh Handedness Inventory (R. C. Oldfield, 1971). *N*s = 100.

male sexual orientation, we performed a logistic regression with these predictor variables entered directly into the model. Table 3 shows each coefficient as *B*, which represents a change in the logarithmic odds of homosexuality for a one-unit increment in the relevant predictor, controlling for other predictors in the equation, and the term e^B represents the corresponding percentage change (Tabachnick & Fidell, 2006). The only significant predictor was number of older brothers; each older brother increased the odds of homosexuality by 41% in the present sample.

Discussion

The current data show no difference between heterosexual and homosexual men in the number of counterclockwise hair whorls. This is the first study to use a methodology unbiased by experimenter's imprecise evaluations of hair whorl patterns and sexuality. We also found no association between hair whorl direction and handedness (using a continuous measure) but confirmed the well-established fraternal birth-order effect.

This study is inconsistent with one widely reported study of hair whorl direction and sexual orientation (Klar, 2004). While the present investigation had a smaller sample size in comparison with that of Klar (2004), this is unlikely to have contributed to the observed inconsistency. We computed effect sizes from Klar's (2004) article using *w* for chi-square tests (Cohen, 1988). The effect size for Klar's main comparison is 0.59, a large effect by Cohen's conventions (Cohen, 1988). Using this effect size, the present study would have required a total *n* of 23 to detect a significant difference at an alpha level of 0.05 with statistical power at 81%. Even if the smallest effect size from Klar (2004) is used ($w = 0.40$; derived from the χ^2 analysis of the second sample of presumed gay men in that study), we would need 50 participants in total to detect a significance difference at 80% power. Therefore, the present study had a sufficient sample size to detect statistically significant group differences in hair whorl direction had they existed. It is unlikely that our sample is anomalous in some manner given that the overall rate of counterclockwise whorls observed corresponds to those found in two studies using similar, or larger, samples than ours (e.g., Beaton & Mellor, 2007; Jansen et al., 2007). We also replicated a well-known biodemographic correlate of male sexual orientation—greater number of older brothers among homosexual men—reported independently in several countries (Blanchard, 2004, 2008). Our data are consistent with other failed attempts to associate hair whorls with neurobehavioral traits for which sex differences are known, such as schizophrenia and functional measures of language lateralization (Jansen et al., 2007; Puri et al., 1995; Yousefi-Nooraie & Mortaz-Hedjri, 2008).

The lack of an association between hair whorl direction and handedness reported in this study is somewhat supportive of several previous studies (Annett, 1985; Jansen et al., 2007; Newman, 1934). However, this is not overly informative, given the somewhat restricted variation in handedness scores here toward predominantly right-handed individuals (there were only 21 left-handers on the basis of our criteria), so caution is warranted in drawing too strong a conclusion. Nonetheless, we were able to demonstrate that older brothers (and no other type of sibling) increased the odds of homosexuality in men, as has been shown previously (for comparable odds, see Blanchard & Bogaert, 1996, and Blanchard et al., 1998). This is supportive of a neurodevelopmental hypothesis based on incremental maternal immunization to male-linked antigens elicited by carrying successive male fetuses (Blanchard, 2004). We did not find a relationship between handedness and sibling sex composition measures reported in some studies, although this is not surprising, given the predominantly right-handed nature of our sample (e.g., Blanchard et al., 2006). The finding here that an elevated number of counterclockwise hair whorls was related to having more older sisters among heterosexual men appears to be a random result and its significance is unclear.

The present study had significant advantages over that of Klar (2004), and more general studies of hair whorl patterns, in terms of objectively recording hair whorl direction, but several limitations are worthy of note. We cannot exclude the possibility that patterns of hair whorls other than the one used in this study (i.e., possessing one hair whorl in one of two directional rotations only) relates to sexual orientation. Future investigations might consider that variant hair whorl patterns (such as two whorls) are better indicators of prenatal developmental events or developmental instability that also happen to predict sexual orientation. Our data do not shed light on the putative relationship between hair whorl direction and sexual orientation in women, which requires future investigation. Nor are the present results informative about particular biological mechanisms proposed to be responsible for the development of

Table 3
Logistic Regression of Sexual Orientation on the Predictor Variables

Predictor variable	*B*	*SE*	Wald	*p*	e^B
Number of older brothers	0.35	0.17	4.37	0.04	1.41
Number of older sisters	0.11	0.19	0.40	0.53	1.12
Number of younger brothers	−0.35	0.27	1.70	0.19	0.70
Number of younger sisters	0.001	0.24	0.00	0.99	1.00
Handedness scores	0.004	0.003	1.60	0.21	1.00
Counterclockwise hair whorls	−0.22	0.41	0.30	0.59	0.80

Note. Handedness was measured with the Edinburgh Handedness Inventory (R. C. Oldfield, 1971) and is scored from −100 (left handed) to +100 (right handed). Sexual orientation was dichotomized as 0 (heterosexual) and 1 (homosexual). Counterclockwise hair whorls are scored as 0 (not present) and 1 (present).

hair whorl patterns or sexual orientation, such as prenatal androgen exposure, developmental instability or genetic models in which a single gene affects neural, somatic, and praxic asymmetries (Klar, 2003; Rahman, 2005b). If in future a relationship between hair whorl direction and sexual orientation were objectively demonstrated, it would be hard to see how sexual orientation in some men could be organized by cultural or social factors given that hair whorl patterns are immune to these by virtue of their fetal ontogenesis.

In conclusion, the data presented here show no differences between heterosexual and homosexual men in the direction of objectively measured hair whorls. Therefore this study does not support the notion that hair whorl patterns are a meaningful neurodevelopmental marker of male sexual orientation. The research effort on replicable "biomarkers," such as fraternal birth order—as demonstrated here—should continue and their underlying developmental mechanisms be targeted for further investigation.

References

Annett, M. (1985). *Left, right, hand and brain: The right shift theory.* London: Erlbaum.

Bailey, J. M., Dunne, M. P., & Martin, N. G. (2000). Genetic and environmental influences on sexual orientation and its correlates in an Australian twin sample. *Journal of Personality and Social Psychology, 78,* 524–536.

Beaton, A. A., & Mellor, G. (2007). Direction of hair whorl and handedness. *Laterality, 12,* 295–301.

Blanchard, R. (2004). Quantitative and theoretical analyses of the relation between older brothers and homosexuality in men. *Journal of Theoretical Biology, 230,* 173–187.

Blanchard, R. (2008). Review and theory of handedness, birth order, and homosexuality in men. *Laterality, 13,* 51–70.

Blanchard, R., & Bogaert, A. F. (1996). Homosexuality in men and number of older brothers. *American Journal of Psychiatry, 153,* 27–31.

Blanchard, R., Cantor, J. M., Bogaert, A. F., Breedlove, S. M., & Ellis, L. (2006). Interaction of fraternal birth order and handedness in the development of male homosexuality. *Hormones and Behavior, 49,* 405–414.

Blanchard, R., & Lippa, R. A. (2007). Birth order, sibling sex ratio, handedness, and sexual orientation of male and female participants in a BBC internet research project. *Archives of Sexual Behavior, 36,* 163–176.

Blanchard, R., Zucker, K. J., Siegelman, M., Dickey, R., & Klassen, P. (1998). The relation of birth order to sexual orientation in men and women. *Journal of Biosocial Science, 30,* 511–519.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Collins, R. L. (1977). Origins of the sense of asymmetry: Mendelian and non-Mendelian models of inheritance. *Annals of the New York Academy of Sciences, 299,* 283–305.

James, W. H. (1987). The human sex ratio: 1. A review of the literature. *Human Biology, 59,* 721–752.

Jansen, A., Lohmann, H., Scharfe, S., Sehlmeyer, C., Deppe, M., & Knecht, S. (2007). The association between scalp hair whorl direction, handedness and hemispheric language dominance: Is there a common genetic basis of lateralization? *NeuroImage, 35,* 853–861.

Kinsey, A. C., Pomeroy, W. B., & Martin, C. E. (1948). *Sexual behavior in the human male.* Philadelphia: Saunders.

Klar, A. J. S. (2003). Human handedness and scalp hair whorl direction develop from a common genetic mechanism. *Genetics, 165,* 269–276.

Klar, A. J. S. (2004). Excess of counter-clockwise scalp hair-whorl rotation in homosexual men. *Journal of Genetics, 83,* 251–255.

Lalumiere, M. L., Blanchard, R., & Zucker, K. J. (2000). Sexual orientation and handedness in men and women: A meta-analysis. *Psychological Bulletin, 126,* 575–592.

Långström, N., Rahman, Q., Carlström, E., & Lichtenstein, P. (in press). Genetic and environmental effects on same-sex sexual behavior: A population study of twins in Sweden. *Archives of Sexual Behavior.*

McFadden, D., Loehlin, J. C., Breedlove, S. M., Lippa, R. A., Manning, J. T., & Rahman, Q. (2005). A reanalysis of five studies on sexual orientation and the relative length of the 2nd and 4th fingers (the 2D:4D ratio). *Archives of Sexual Behavior, 34,* 341–356.

Morris, J. A., Jordan, C. J., & Breedlove, S. M. (2004). Sexual differentiation of the vertebrate nervous system. *Nature Neuroscience, 7,* 1034–1039.

Mustanski, B. S., DuPree, M. G., Nievergelt, C. M., Bocklandt, S., Schork, N. J., & Hamer, D. H. (2005). A genomewide scan of male sexual orientation. *Human Genetics, 116,* 272–278.

Newman, H. H. (1934). Dermatoglyphics and the problem of handedness. *American Journal of Anatomy, 55,* 277–322.

Oldfield, R. C. (1971). The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsychologia, 9,* 97–113.

Puri, B. K., El-Dosoky, A., Cheema, S., Lekh, S. K., Hall, A. D., & Mortimer, A. M. (1995). Parietal scalp hair whorl patterns in schizophrenia. *Biological Psychiatry, 37,* 278–279.

Rahman, Q. (2005a). Fluctuating asymmetry, 2nd to 4th finger length ratios and human sexual orientation. *Psychoneuroendocrinology, 30,* 382–391.

Rahman, Q. (2005b). The neurodevelopment of human sexual orientation. *Neuroscience and Biobehavioral Reviews, 29,* 1057–1066.

Scott, N. M., Weinberg, S. M., Neiswanger, K., Brandon, C. A., & Marazita, M. L. (2005). Hair whorls and handedness: Informative phenotypic markers in nonsyndromic cleft lip with or without cleft palate (NS CL/P) cases and their unaffected relatives. *American Journal of Medical Genetics, 136,* 158–161.

Smith, D. W., & Gong, B. T. (1974). Scalp hair patterning: Its origins and significance relative to early brain and upper facial development. *Teratology, 91,* 17–34.

Tabachnick, B. G., & Fidell, L. S. (2006). *Using multivariate statistics* (5th ed.). Needham Heights, MA: Allyn & Bacon.

Tirosh, E., Jaffe, M., & Dar, H. (1987). The clinical significance of multiple hair whorls and their association with unusual dermatoglyphics and dysmorphic features in mentally retarded Israeli children. *European Journal of Pediatrics, 146,* 568–570.

Wunderlich, R. C., & Heerema, N. A. (1975). Hair crown patterns of human newborns. *Clinical Pediatrics, 14,* 1045–1049.

Yousefi-Nooraie, R., & Mortaz-Hedjri, S. (2008). Dermatoglyphic asymmetry and hair whorl patterns in schizophrenia and bipolar patients. *Psychiatry Research, 157,* 247–250.

Received October 22, 2008
Revision received November 19, 2008
Accepted November 20, 2008 ■