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Handedness and Sexual Orientation*

David W. Holtzen
Department of Psychiatry, The Cambridge Hospital/Harvard Medical School

ABSTRACT

Surveys of *handedness distribution* (i.e., the distribution across handedness categories in large samples, typically based upon self-reported right-, mixed- and left-handed classification) indicate approximately 90% of the population is right-handed (Springer & Deutsch, 1989). This distribution toward right-handedness has been called *right shift* based on a genetic model (Annett, 1985). The present study examined possible handedness distribution differences between 141 gay, lesbian, and bisexuals and 260 heterosexuals who have a homosexual/bisexual first-degree (biological) relative. Based on a five-category self-assessment handedness questionnaire that was validated using Briggs and Nebes' (1975) reformulation of Annett's inventory (1970), non-heterosexuals showed a reduction of right shift compared to heterosexuals (i.e., a population shift toward mixed- and left-handedness), confirming the results of Lindesay (1987) and Becker et al., (1989). Sexual orientation also weakly predicted handedness. The findings indirectly support the hypothesis of Geschwind and Galaburda (1985a, 1985b) that sexual orientation and handedness may be linked, both possibly influenced prenatally by testosterone. The discussion emphasizes (a) the meaninglessness in distinguishing genetic from hormonal influences and (b) non-heterosexually biased assumptions about human sexuality.

Geschwind and his associates (Galaburda, Corsiglia, & Rosen, 1987; Geschwind & Behan, 1982, 1984; Geschwind & Galaburda, 1985a, 1985b, 1987) have theorized that prenatal hormones, especially testosterone, might affect four seemingly unrelated phenomena: hemispheric specialization (viz., language functions and handedness); immune functioning; learning (viz., reading); and sexual orientation. Their speculations have generated much research. One line of inquiry has examined whether or not these four broad areas are directly related to hormone levels *in utero*. Stereotypic female sexual behavior (lordosis), for example, has been found to occur in male animals exposed to high levels of intrauterine testosterone (Ward, 1984). Another line of inquiry has examined possible intercorrelations among laterality, sexuality, learning, and immune system functioning in humans. For example, studies examining possible handedness differences between homosexuals and heterosexuals have been pursued.

Geschwind and Galaburda (1985b) have indicated that the study of handedness in homosexuals is worthwhile, since intrauterine testosterone may play a role in both sexuality and handedness. Although they have not specifically hypothesized that homosexual populations have a higher incidence of left-handedness than heterosexual populations, Geschwind and Galaburda (1985b) have stated that an increased rate of left-handedness would be consistent with animal research and their theory of testosterone's role *in utero*.

The focus of the present study is to test Geschwind and Galaburda's hypothesis (1985a, 1985b) that both sexual orientation and handed-

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Address correspondence to: David W. Holtzen, Ph.D., 28 Waban Avenue, Waban, MA 02168, U.S.A.
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ness may share a common hormonal substrate by (a) comparing the handedness distribution between heterosexuals and non-heterosexuals and (b) examining whether sexual orientation predicts handedness.

The results regarding an association between handedness and sexual orientation have been equivocal. Some (e.g., Marchant-Haycox, McManus, & Wilson, 1991; Rosenstein & Bigler, 1987; Satz et al., 1991; Tkachuk & Zucker, 1991) have found no significant association between handedness distribution and sexual orientation. Others (e.g., Becker et al., 1989; Lindesay, 1987) have found a significant leftward shift in the handedness distribution of homosexuals, or as argued (Annett, 1988), a reduction of right shift. The data from one study (McCormick, Witelson, & Kingstone, 1990) suggests a reduction of right shift for homosexual women, but not for homosexual men. (*Right shift* refers to the distribution of hand usage in a population – typically categorized as right, mixed- or left-handed – which reflects the fact that an overwhelming majority use their right hand for unimanual tasks, such as handwriting. Relatedly, *handedness* refers to any given individual's typical hand usage for unimanual tasks, which is also often divided into right, mixed and left categories.) Furthermore, general population data (Lansky, Feinstein, & Peterson, 1988) showing a higher incidence of nonright-handedness in unmarried persons might also be explained by homosexuality (James, 1989). A reduction of right shift in homosexual populations, if one exists, would support the hypothesis of Geschwind and Galaburda (1985a, 1985b) that handedness and sexuality may be influenced by a common factor (viz., testosterone).

To some extent these inconsistent findings may reflect the following methodological shortcomings found in the literature that make drawing conclusions tentative: (a) having a small sample size (Lindesay, 1987; McCormick et al., 1990; Rosenstein & Bigler, 1987; Tkachuk & Zucker, 1991); (b) sampling gay males, but not lesbians (Becker et al., 1989; Lindesay 1987; Marchant-Haycox et al., 1991; Satz et al., 1991); (c) failing to include a heterosexual comparison group (Becker et al., 1989; McCormick et al., 1990; Satz et al., 1991); (d) failing to adequately define or measure handedness (Marchant-Haycox et al., 1991; Satz et al., 1991); and (e) failing to properly measure sexual orientation (Rosenstein & Bigler, 1987).

Because presumed handedness differences between heterosexual and homosexual populations are assumed to be small, obtaining large samples is necessary. In addition, because the hypothesis regarding a possible association between sexual orientation and laterality is not gender-specific, examining handedness in male and female heterosexual and homosexual populations is required. While several studies (Becker et al., 1989; McCormick et al., 1990; Satz et al., 1991) have compared homosexual data to general population data, this approach is not recommended because it violates a fundamental principle of statistics (i.e., sampling from mutually exclusive populations). The inconsistency of at least some data might also be explained by measurement differences and/or handedness classification, the latter often being arbitrarily defined (Springer & Deutsch, 1989).

A reliable and valid instrument that is sensitive to mixed-handed individuals (e.g., Annett, 1970; Briggs & Nebes, 1975) is required in order to properly examine handedness distribution. Such measurements were used by some (Becker et al., 1989; Lindesay, 1987). Others, however, either ignored mixed handedness altogether (Marchant-Haycox et al., 1991) or did not validate their handedness measure with a known measure sensitive to mixed handedness (Satz et al., 1991).

Because there is evidence (Galaburda et al., 1987) in normal brains demonstrating graded asymmetry in one structure (viz., the planum temporale), it has been suggested "that future studies investigating the relationships among laterality, behavior and other biological features avoid setting up arbitrary boundaries between groups, and deal instead with graded laterality measures such as handedness scores and asymmetry coefficients" (pp. 858-859). Discrete data divided into *left*, *right* and *mixed* or into *nonright* and *right* handedness categories, therefore, might not be sufficient in discrimi-

nating among the myriad possibilities of brain asymmetry. This too may account for conflicting findings between studies. While continuous data (i.e., scores) are preferable, research efforts using discrete data should consider using more than three handedness categories. A high agreement between continuous and discrete data should also be reported to insure the validity of the latter.

Like handedness (Annett, 1967), sexual orientation has been argued to be best described as a continuous phenomenon (Kinsey, Pomeroy, & Martin, 1948). It has been operationally defined based on self-labelling (i.e., heterosexual, bisexual, or homosexual) and on history (i.e., the seven-category Kinsey scale). Despite the advantage that the Kinsey scale discriminates among a spectrum of sexual orientation possibilities, it has led to inaccurate categorization of participants. In one study (Rosenstein & Bigler, 1987) that did not find laterality differences between heterosexuals and homosexuals, only five males and no females were exclusively homosexual according to Kinsey's criteria. Overall, 28 of the 38 participants were clearly much nearer the heterosexual end of the Kinsey spectrum than they were to the homosexual end. For the sake of clarity, simplicity, and making comparisons across studies, using self-defined sexual orientation categories appears preferable when anonymity is insured.

Despite methodological problems, some reports (Becker et al., 1989; Lindesay, 1987; McCormick et al., 1990) indicate that increased nonright-handedness in homosexuals may exist. Theoretically, a meta-analysis of the published data could answer the question of possible laterality differences; however, the utility of such a procedure is questionable given the various ways researchers have assessed and/or classified handedness. Therefore, the conflicting findings provoke further exploration.

The aforementioned shortcomings, coupled with findings (Springer & Deutsch, 1989) that: (a) nonright-handedness runs in families; (b) twins have twice the rate of nonright-handedness as singletons; and, (c) postnatal events such as severe childhood head injury account for a minority of nonright-handedness, indicate that a large sample of non-head-injured, self-identified heterosexual and non-heterosexual singletons from the same families be sampled. Controlling for twinning and family background has not been previously reported, while assessing for prior head injury has been controlled for only occasionally. Because severe head injury in childhood and twinning are relatively uncommon and because there is no reason to believe that either of these phenomena occur in heterosexuals moreso than in homosexuals (and vice versa), both are likely to be seen as having negligible statistical effects. Nevertheless, if handedness differences between heterosexual and homosexual populations do exist, they are expected to be of a small magnitude (Geschwind & Galaburda, 1985a, 1985b). Thus, with small sample sizes, even one participant whose nonright-handedness was influenced by head injury or by twinning could obscure the findings, either by demonstrating differences where they do not exist or by masking differences where they do exist.

The aim of the present study is to examine the handedness of gay men, lesbians, and bisexuals and their heterosexually oriented biological parents and siblings and to examine whether sexual orientation predicts handedness. Support for Geschwind and Galaburda's hypothesis would be offered if the incidence of nonright-handedness is significantly greater in the homosexual/bisexual sample than in a sample of their heterosexual family members. Conversely, the hypothesis would not be supported if: (a) similar incidences of nonright-handedness are found in the two groups; or (b) nonright-handedness is found at a higher incidence in the heterosexual sample. Weak support for the hypothesis would be offered if an increased incidence of nonright-handedness were found in both samples, because it could be argued that the nonright-handedness in the non-heterosexual sample is, in part, an artifact of familial handedness. However, a sample of heterosexuals without a non-heterosexual family member would also need to be examined; this was outside the scope of the present study.

METHOD

Subjects

Two groups comprised the sources from which the participants were drawn: (a) heterosexual (HET) parent members of the national support group, Parents and Friends of Lesbians and Gays (PFLAG), and their gay/lesbian/bisexual (GLB) and HET children; and, (b) self-identified GLB university students who attend their school's GLB support/social group and their HET parents and siblings. All GLB participants and their HET siblings self-reported whether or not they were a twin. All participants who completed the handedness inventory reported whether or not they had ever suffered a severe head injury. Persons whose handedness may have been determined by the effects of twinning or severe head trauma were excluded. Adopted and foster children were also excluded. Participants were volunteers, remained anonymous, and were unaware of the nature of the study.

Procedure

All participants were asked their sexual orientation: *homosexual*, *bisexual*, or *heterosexual*. They were also asked to categorize their handedness on a five-point continuum (similar to the distinction made by Annett [1967] to include mixed-handed individuals) given their preference for five unimanual tasks included on the Edinburgh Handedness Inventory (Oldfield, 1971). The five handedness categories were: *Left Handed Exclusively*, *Left Handed Mostly*, *Mixed Handed*, *Right Handed Mostly* and *Right Handed Exclusively*. The multiple choice categorization question was asked in the following manner: "I usually use which hand when doing the following activities (writing, drawing, throwing, using a toothbrush, using a spoon): (1) my left hand, almost always; (2) usually my left hand; (3) my left and right hands equally; (4) usually my right hand; or (5) my right hand, almost always."

Finally, a random minority of participants were asked to complete Annett's handedness inventory (AHI) scored according to Briggs and Nebes' (1975) classification to assess for strength of handedness. This has been reported to be a valid and reliable instrument and scoring procedure (Loo & Schneider, 1979). Scores range from –24 to +24 with classification trifurcated in the following manner. Scores from –24 to –9 are categorized *Left handed*; scores from –8 to +8 are categorized *Mixed handed*; and scores from +9 to +24 are categorized *Right handed*.

Participants self-categorized their handedness before completing the AHI, so the question of how highly these participants' self-categorization matched their actual handedness score and their Briggs-Nebes categorization could be answered. High agreement would indicate that participants were adequate self-categorizers, thus allowing data analyses for all participants. Low agreement, on the other hand, would mandate that only the participants who completed the AHI be used for statistical analyses.

Self-categorization was considered adequate if it matched the Briggs-Nebes AHI category or was one category away from matching it. In other words, categorizing oneself as either *Exclusively Right Handed* or *Mostly Right Handed* were considered adequate self-assessments of handedness if one received a Briggs-Nebes AHI categorization of *Right Handed*. Categorizing oneself as either *Exclusively Left Handed* or *Mostly Left Handed* were considered adequate self-assessments of handedness if one received a Briggs-Nebes AHI categorization of *Left Handed*. Categorizing oneself as using both hands equally (i.e., *Mixed Handed*) was only considered adequate if the Briggs-Nebes AHI category was also *Mixed Handed*.

Fifty-seven PFLAG chapters throughout the United States were invited to participate as part of a larger study (Holtzen, 1993). These chapters were mailed the materials and parents were asked to participate. They were asked to invite their GLB children to participate as well. Parents whose GLB children were adults living away from home were asked either to mail to their children the materials or to provide the names and addresses of their children so that materials could be mailed directly to them. In a minority of instances GLB members of PFLAG participated. They were asked to invite their HET parents and HET siblings to participate in a similar manner.

Once completed, the materials were returned by mail to the investigator. Anonymity was insured by identifying the participant only by code number. Members from the same family had the same code number so that handedness within families could be analyzed.

Eight state university GLB student groups were also invited to participate. The GLB students participated in the same fashion as the PFLAG parents (i.e., they were asked to invite their HET parents and siblings to participate). For both groups, it was expected that some participants would choose not to invite their families to participate.

RESULTS

Of the 888 questionnaires mailed, 431 members from 257 different families participated, representing a return rate of 48.5%. Of the 431 participants, 30 persons were excluded from data analysis: 18 nonbiological (i.e., adopted and foster) family members; 5 co-twins; 2 who reported a history of severe head injury; 4 who did not respond to the handedness question;

and, 1 who did not respond to the sexual orientation question. One hundred forty-one completed, analyzable questionnaires were returned by GLB persons (119 from those associated with PFLAG, 22 from college students). Two hundred sixty completed, analyzable questionnaires were returned by HET persons (254 associated with PFLAG, 6 related to GLB college students). Of the GLB participants, 65.2% had at least one HET family member participate.

Demographic characteristics revealed that most participants were well-educated White persons (Table 1). Of the HETs, 86.1% had at least some college education, while 93.5% of the GLBs had at least some college education. Nearly all of the participants were White (96.5%). HETs were, not surprisingly, more likely to be married or to have been married (95.4%) than were their GLB family members (8.8%). Since most HETs were the parents of the GLBs, the HET group was also older than the GLB group. Participants were represented from 30 states of diverse geographical location: West/Pacific (22.9%); Plains/Mountains (7.5%); Midwest (23.9%); South (17.8%); and East (27.9%). Nine of the 10 bisexual participants were women.

For the small percentage (56/401) who completed the AHI, dissimilar J-shaped skewness between the 32 HET and 24 GLB participants was found (–2.6 and –1.4, respectively). The GLB group had a lower mean AHI score than the HET group (GLB = 12.5 +/– 15.2; HET = 18.0 +/– 10.1), which was not significant (t = 1.65, $p > .05$, 54 *df*). When categorized according to Briggs-Nebes' procedure (1975), a higher proportion of nonright-handed individuals was found in the GLB group as follows: GLB: *Left handed*: 4/24 (16.7%); *Mixed handed* 2/24 (8.3%); *Right handed* 18/24 (75%); HET: *Left handed*: 2/32 (6.3%); *Mixed handed* 1/32 (3.1%); *Right handed* 29/32 (90.6%). However, a Chi-square test of association revealed that this higher proportion was not statistically significant ($X^2 = 2.482$, $p = .2891$, 2 *df*).

Self-categorized handedness, as assessed by the five-category handedness question, proved highly comparable to the AHI data. Only two participants (3.6%) who completed the AHI, both heterosexual, did not categorize their handedness in a way that corresponded to their AHI self-report. One reported being *Exclusively Right Handed*, but was actually *Left handed* according to the AHI; the other reported being *Mostly Left Handed*, but was actually *Right handed*. Thus, all participants who answered the handedness question were included in further analyses.

Upon inspection, the frequency distribution of self-reported handedness indicates that a reduction of right shift may exist (i.e., a population shift toward mixed- and left-handedness) in the non-heterosexual participants (Table 2). Heterosexual males demonstrated a higher percentage of exclusive right handedness compared to gay and bisexual males (80.5% vs. 63.5%, respectively) and a lower percentage of exclusive left handedness (4.9% vs. 11.7%, respectively). Similarly, heterosexual females demonstrated a higher percentage of exclusive right handedness compared to lesbian and bisexual females (77.0% vs. 60.7%, respectively), although the percentage of exclusive left handedness was similar (7.3% vs. 7.1%, respectively). Five each of the 10 bisexual participants reported being *Mostly Right Handed* and *Exclusively Right Handed*. Also of note is that HETs had an incidence of left handedness (7.3%) – defined by *Exclusively Left Handed* and *Mostly Left Handed* self-categorization responses – that closely approximated a sample (Lansky et al., 1988) of the general population (7.2%). Conversely, GLBs had an incidence of left handedness of 14.2%.

Because handedness distribution differences between men and women have been reported in the general population (Lansky et al., 1988), data analyses were performed separately by gender. Regression analyses were used as were Chi-square tests of association. (All Chi-square analyses are based on the more stringent continuity correction Chi-square value.) Simple regression analyses were used to determine whether sexual orientation predicts handedness. Chi-square analyses were used to determine whether or not HET and GLB groups have different handedness distributions from one another (i.e., differences in rates of exclusive vs. non-exclusive right handedness).

Table 1. Demographic Characteristics by Sexual Orientation.

	Heterosexuals[a]	Homosexuals/Bisexuals[b]
Age (years)		
Mean	54.9	30.0
SD	10.9	8.0
Range	20-84	17-58
Sex		
Male	82 (31.5)	85 (60.3)
Female	178 (68.5)	56 (39.7)
Race		
White	257 (98.8)	130 (92.2)
Black	2	1
Latino	1	1
Native American	0	2
No Response/Other	0	7
Highest Educational Attainment		
Middle School or less	2 (0.8)	1 (0.7)
High School	34 (13.1)	8 (5.8)
Some College	79 (30.4)	50 (36.0)
College Graduate	58 (22.3)	43 (30.9)
Post-college Graduate	87 (33.4)	37 (26.6)
Current Relational Status		
Never married/not cohabitating	6 (2.3)	68 (50.0)
Currently married, married once	166 (63.8)	2 (1.5)
Separated/Divorced/Remarried	63 (24.2)	10 (7.4)
Unmarried, cohabitating with mate	6 (2.3)	56 (41.2)
Widowed, not remarried	19 (7.3)	0

Note: [a]$n = 260$. [b]$n = 141$. Percentages are in parentheses.

Compared to HET men, gay and bisexual men demonstrated a significantly different handedness distribution in that they demonstrated a greater degree of non-exclusive right handedness ($X^2 = 5.126$, $p = .0236$, 1 *df*). Furthermore, for men, sexual orientation predicted handedness [$F(1, 165) = 5.451$, $p = .0208$]. As expected, the power of prediction was small; sexual orientation accounted for only 2.6% of the variance (adjusted $R^2 = .026$).

Lesbian and bisexual women also demonstrated a significantly different distribution compared to their HET counterparts in that they evidenced a greater degree of non-exclusive right handedness ($X^2 = 4.923$, $p = .0265$, 1 *df*). For women, sexual orientation also significantly predicted handedness [$F(1, 232) = 4.063$, $p = .045$], accounting for 1.3% of the variance (adjusted $R^2 = .013$).

To strictly control for family handedness and

Table 2. Frequency of Self-Reported Handedness by Sexual Orientation and Gender.

	Self-Reported Handedness Category (% of n)				
Sexual Orientation	Left Handed	Left Handed	Mixed Handed	Right Handed	Right Handed
Gender	Exclusively	Mostly		Mostly	Exclusively
Heterosexuals[a]*:*	17 (6.5)	2 (0.8)	4 (1.5)	34 (13.1)	203 (78.1)
Male (n = 82)	4 (4.9)	0 (0.0)	2 (2.4)	10 (12.2)	66 (80.5)
Female (n = 178)	13 (7.3)	2 (1.1)	2 (1.1)	24 (13.5)	137 (77.0)
Homosexuals/Bisexuals[b]*:*	14 (9.9)	6 (4.3)	5 (3.5)	28 (19.9)	88 (62.4)
Male (n = 85)	10 (11.7)	2 (2.4)	2 (2.4)	17 (20.0)	54 (63.5)
Female (n = 56)	4 (7.1)	4 (7.1)	3 (5.4)	11 (19.6)	34 (60.7)
All Participants[c]*:*	31 (7.7)	8 (2.0)	9 (2.2)	62 (15.5)	291 (72.6)
Male (n = 167)	14 (8.4)	2 (1.2)	4 (2.4)	27 (16.2)	120 (71.8)
Female (n = 234)	17 (7.3)	6 (2.5)	5 (2.1)	35 (15.0)	171 (73.1)

Note: [a]n = 260. [b]n = 141. [c]N = 401. Percentages are rounded.

gender, same-sex members of the same families (e.g., gay men and their HET fathers/brothers) were also to be compared to each other. However, only 21 gay men had 23 of their heterosexual fathers and/or brothers participate and only 30 bisexual/lesbian women had their 33 heterosexual mothers and/or sisters participate. Because so few same-sex, biologic relatives participated, data analyses were not conducted.

Given the significant age differences between the HETs and the GLBs and given that the majority of HETs were women while the majority of GLBs were men, age and gender may have confounded these handedness distribution differences. Therefore, further analyses were conducted to determine what influence, if any, age and gender may have had.

First, a multiple regression analysis examined the predictive power of age, gender, and sexual orientation on handedness. For all participants, the combination of age, gender, and sexual orientation significantly predicted handedness $F(3, 378) = 2.79$, $p = .0404$], which accounted for 1.4% of the variance (adjusted $R^2 = .014$). Examination of the beta coefficients of each variable revealed that sexual orientation, but not age or gender, significantly contributed to the predictive power of the regression model (Sexual Orientation: $\beta = .204$, $p = .0393$; Age: $\beta = -.001$, $p = .8352$; Gender: $\beta = -.083$, $p = .5078$).

Second, Chi-square tests of association compared the handedness of the older half of participants within each group with the younger half. There were no differences in incidences of non-exclusive right handedness in either the GLB group ($X^2 = 0.456$, $p = .4997$, 1 *df*) or the HET group ($X^2 = 0.002$, $p = .9675$, 1 *df*). The mean ages and standard deviations (in years) were as follows: (1) GLBs: Younger half ($M = 24.4$, $SD = 3.0$), Older half ($M = 37.0$, $SD = 6.7$); and (2) HETs: Younger half $M = 46.2$, $SD = 8.0$), Older half ($M = 63.0$, $SD = 6.0$).

Third, three Chi-square tests of association revealed no gender differences in handedness distribution: (1) all women were compared to all men ($X^2 = 1.211$, $p = .8763$, 4 *df*); (2) lesbian/bisexual women were compared to gay/bisexual men ($X^2 = 3.451$, $p = .4854$, 4 *df*); and (3) heterosexual women were compared to heterosexual men ($X^2 = 2.218$, $p = .6957$, 4 *df*). These analyses indicate that the handedness distribution differences found between the HET groups and the GLB groups were not confounded by either age or gender. Overall, the data indicate that, compared to their HET counter-

parts, GLB participants evidenced a statistically significant reduction of right shift (i.e., a population shift toward mixed- and left-handedness). Sexual orientation (weakly) predicted handedness in males and in females.

Finally, in light of a recent finding (LeVay, 1991) demonstrating neuroanatomical differences between both homosexual men and heterosexual women compared to heterosexual men, an analysis of association was performed (excluding the 10 bisexual participants) vis-à-vis the two sexual attraction categories to which the participants belonged. These categories are androphiles (individuals sexually attracted to men) and gynephiles (individuals sexually attracted to women). Sexual attraction category did not predict handedness [$F(1, 388) = 0.05$, $p = .8236$]. Further, no difference in handedness distribution was found between the androphiles and the gynephiles ($X^2 = 0.009$, $p = .9224$, 1 *df*).

DISCUSSION

This study tested Geschwind and Galaburda's hypothesis (1985a, 1985b) about a possible association between sexual orientation and cerebral lateralization by comparing the handedness distributions of heterosexuals and non-heterosexuals. The revised hypothesis states that increased intrauterine testosterone affects fetal brain development (i.e., degree of asymmetry) in a majority of individuals, not by slowing down the left hemisphere's development (as first believed), but by accelerating right hemisphere growth (Galaburda et al., 1987). Under such conditions, right hemisphere (or bilateral) language functions and non-exclusive right handedness are more likely to occur because these functions are more efficiently performed by the more rapidly developed right hemisphere. Concomitantly, a greater incidence of homosexuality is expected to be found in those with high intrauterine testosterone exposure at certain critical periods of hypothalmic development, followed by low levels at later periods of this brain structure's development.

Using a self-reported measure sensitive to mixed handedness that correlated highly with a valid, widely used measure, the non-heterosexuals in this study demonstrated a significantly higher incidence of non-exclusive right handedness compared to their heterosexually-oriented counterparts. Sexual orientation proved to be a weak, but statistically significant, predictor of handedness in males and in females, accounting for 2.6% and 1.3% of the variance, respectively. Taken together, the results support, albeit indirectly, Geschwind and Galaburda's hypothesis (1985a, 1985b) that intrauterine testosterone may influence to some extent cerebral lateralization and sexual orientation. Since intrauterine testosterone levels could not be known, it is possible that other factors might have accounted for the laterality differences.

It must be emphasized that a statistically significant difference between non-heterosexual and heterosexual adults was found. The majority of homosexual and bisexual participants in this study, like the general population (Lansky et al., 1988), were exclusively right handed. Furthermore, the handedness distribution for both male and female heterosexual and non-heterosexual groups evidenced right-shifted, J-shaped skewness.

When comparing androphiles and gynephiles, no differences in handedness distribution emerged. While a recent neuroanatomical study (LeVay, 1991) that examined a particular area of one brain structure (the anterior hypothalamus) found differences between both gay men and heterosexual women (androphiles) compared to heterosexual men (gynephiles), the current findings suggest that, in terms of laterality, neither male homosexuality and female heterosexuality, nor female homosexuality and male heterosexuality are biologic equivalents of each other.

The present findings confirm the work of some (Becker et al., 1989; Lindesay, 1987), but not others (Marchant-Haycox et al., 1991; Rosenstein & Bigler, 1987; Satz et al., 1991; Tkachuk & Zucker, 1991); the findings of McCormick et al., (1990) are partially supported. There are several methodological and measurement differences that likely account for the disparate findings across studies. First, in this study, as in others which found handedness

differences (Becker et al., 1989; Lindesay, 1987), general population data were not used. Rather, heterosexuals were compared to non-heterosexuals. Second, by assessing mixed handedness, graded laterality has been better measured in some studies (Becker et al., 1989; Lindesay, 1987), than in others (Marchant-Haycox et al., 1991). Third, assessing handedness in women and in bisexual persons of both genders has been ignored often (Becker et al., 1989; Lindesay, 1987; Marchant-Haycox et al., 1991; Satz et al., 1991).

The present study has several shortcomings. First, while larger than samples in many previous reports (Lindesay, 1987; McCormick et al., 1990; Rosenstein & Bigler, 1987; Tkachuk & Zucker, 1991), the sample size in this study was small ($N = 401$). Second, the sample – predominently White of mixed northern European heritage, well-educated, voluntary, and whose familial homosexuality had been disclosed to immediate family members – does not represent the true diversity of populations of heterosexuals and non-heterosexuals in the United States.

Third, it is not known to what extent, if any, participants in this study were forcibly "switched" as children into becoming right handed. Generational (cohort) differences in handedness, likely due to fewer social pressures today than in the past to conform to predominent right hand usage, have been reported (Lansky et al., 1988); this could have been a confounding variable in this study. Despite the age difference between the non-heterosexuals and the heterosexuals, there is evidence that age was not a confounding variable (viz., age was not a significant factor in predicting handedness and no differences were found between the younger half and the older half of the heterosexual and homosexual groups). Nonetheless, participants were not asked whether their handedness resulted from coercion.

Fourth, while twins and persons who reported prior head injury (factors known to be associated with nonright-handedness) were excluded from data analysis, this information was not available from all participants. Information on twinning was available for all homosexual/bisexual participants and their heterosexual siblings; however, it was not available for heterosexual parents. Head-injury assessment was obtained only from those who completed the Annett Handedness Inventory (i.e., 14% of the sample).

Fifth, only a small number of bisexual individuals participated (viz., nine females and one male). Therefore, until more complete data are obtained, definitive conclusions about handedness distribution and sexual orientation cannot be made.

Keeping the methodological shortcomings in mind, the findings suggest a reduction of right shift in gay and lesbian populations. Furthermore, because in this study homosexuals were compared to heterosexuals who had a homosexual first-degree family member, it is suggested that increased nonright-handedness in homosexual samples found here, and perhaps elsewhere (Becker et al., 1989; Lindesay, 1987; McCormick et al., 1990), can not be fully explained by the fact that nonright-handedness runs in families.

Because handedness is a neuropsychological index of hemispheric lateralization (Lezak, 1983; Springer & Deutsch, 1989), it can be used to test biologically focused hypotheses about the origins of sexual orientation when both are hypothesized to be somehow related. Conclusions about possible biological bases for sexual orientation cannot be made without confirming neurological, endocrinological, neuroanatomical, genetic, and further neuropsychological data in humans. The present findings do suggest, however, a biological substrate which is consistent with a budding literature on the biology of sexual orientation (Bailey & Benishay, 1993; Bailey & Pillard, 1991; LeVay, 1991). While thus far poorly understood, sexual orientation probably involves complex biologic-environmental substrates.

Lindesay (1987) speculated whether a reduction of right shift in homosexual samples is due to an increased absence of a right shift gene (rs) as originally proposed by Annett (1985). According to the *right shift theory*, this gene is presumed to be responsible for left hemisphere language dominance and right-handedness. The gene's two alleles – one usually dominant (rs+)

and the other usually recessive (rs-) – produce three genotypes. Two are homozygotes (rs++ and rs--) and the other is a heterozygote (rs+-). The theory postulates that most individuals inherit the gene – either from both parents (rs++), or from only one (rs+-); some, however, do not (rs--). Non-genetic factors can also influence handedness. For example, the handedness of the rs+-genotype might be partially determined – and the handedness of the rs-- genotype is hypothesized to be completely determined – by social and chance factors according to the right shift theory. If Lindesay's speculation is correct, then one would expect that, in addition to homosexuals, the first-degree relatives of homosexuals would also have an increased incidence of rs-- and rs+- genotypes. Homosexuals and their heterosexual relatives, therefore, would be expected to (a) have an increased reduction of right shift compared to heterosexuals without familial homosexuality and (b) have similar handedness distribution patterns compared to each other. The present study fails to support the latter expectation and current data is lacking on the first.

Contrasting with Lindesay's speculation, Annett (1988) noted that possible explanations for a reduction of right shift in homosexuals include: (a) genotype differences between heterosexuals and non-heterosexuals (à la Lindesay); (b) so-called non-genetic factors which influence handedness whether the gene is present or not (primarily in the rs+- and rs-- genotypes); or (c) both. That the data presented in this study and elsewhere (Bailey & Benishay, 1993; Bailey & Pillard, 1991; Springer & Deutsch, 1989) do not support a strictly genetic formulation about either the etiology of handedness or sexual orientation further indicates that examining the origins of human sexuality and cerebral lateralization is complex and, therefore, should include multiple factors.

Replicating the present study with a much larger sample will refute or confirm the within-family handedness distribution difference found between heterosexual and non-heterosexual men and women. Future studies also need to obtain family handedness data from a sample of all first-degree relatives with at least one member who is gay, lesbian, or bisexual as well as from a sample of all first-degree relatives without a homosexual or bisexual family member. Such a design could test whether handedness distribution differs between: (a) heterosexuals and non-heterosexuals only; (b) non-heterosexuals and heterosexuals with familial homosexuality or bisexuality; and, (c) heterosexuals with and without familial homosexuality/bisexuality.

Using handedness scores are recommended (Galaburda et al., 1987) over using arbitrarily defined handedness categories, because: (a) compared to discrete data, continuous data can better measure handedness distribution; and (b) identical handedness measures across studies allow between-study comparisons and meta-analyses. Nevertheless, nearly all participants in this study accurately self-categorized their handedness which took into account a spectrum of variability, suggesting categorical data can be sensitive to measure handedness distribution if queried properly. Because of its ease of administration, its ability to sensitively measure handedness distribution and its accuracy with an instrument which assesses mixed handedness, a measure like the one used here is recommended for future studies only if more preferable instruments (i.e., valid ones that use scores) cannot be used. Controlling for twinning, head injury, and the effects of coerced right handedness should be routine in future studies.

Finally, other neuropsychological studies involving sexuality need to control for handedness, because the conflicting findings of studies (Gladue, Beatty, Larson, & Staton, 1990; Sanders & Ross-Field, 1986; Wilmott & Brierley, 1984) examining possible sexual orientation differences on verbal and visuospatial tasks may be due to between-group handedness differences.

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