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Interaction of fraternal birth order and handedness in the development of male homosexuality

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Abstract

The present study investigated evidence for an interaction between two of the best established etiologic factors, or markers of etiologic factors, in the literature on male homosexuality: fraternal birth order and hand preference. By combining five samples, the authors produced study groups of 1774 right-handed heterosexuals, 287 non-right-handed heterosexuals, 928 right-handed homosexuals, and 157 non-right-handed homosexuals. The results showed a significant ($P = 0.004$) handedness by older brothers interaction, such that (a) the typical positive correlation between homosexuality and greater numbers of older brothers holds only for right-handed males, (b) among men with no older brothers, homosexuals are more likely to be non-right-handed than heterosexuals; among men with one or more older brothers, homosexuals are less likely to be non-right-handed than heterosexuals, and (c) the odds of homosexuality are higher for men who have a non-right hand preference or who have older brothers, relative to men with neither of these features, but the odds for men with both features are similar to the odds for men with neither. These findings have at least two possible explanations: (a) the etiologic factors associated with non-right-handedness and older brothers–hypothesized to be hyperandrogenization and anti-male antibodies, respectively–counteract each other, yielding the functional equivalent of typical masculinization, and (b) the number of non-right-handed homosexuals with older brothers is smaller than expected because the combination of the older brothers factor with the non-right-handedness factor is toxic enough to lower the probability that the affected fetus will survive.

Keywords: Androgen; Antibody; Birth order; Handedness; Homosexuality; Sexual orientation

Introduction

Most researchers who study the origins of sexual orientation believe that homosexuality in human males has multiple causes. Some researchers also acknowledge the possibility that the various etiologic factors that contribute to homosexuality may interact with each other (e.g., Mustanski et al., 2002b)—that the effect of two or more factors together may be quite different from the sum of their effects in isolation. Although such interaction is recognized as a theoretical possibility, it has never been demonstrated empirically in a large-scale study with variables having well established individual effects. The present study therefore investigated evidence for interaction between two of the best established etiologic factors, or markers of etiologic factors, in the literature on male homosexuality: fraternal birth order and hand preference.

A meta-analysis of aggregate data from 14 samples representing 10,143 male subjects has shown that homosexuality in human males is predicted by higher numbers of older brothers, but not by higher numbers of older sisters, younger brothers, or younger sisters (Blanchard, 2004). The relation between number of older brothers and sexual orientation holds only for males. This phenomenon has therefore been called the *fraternal birth order effect*.

Blanchard (2004) included in his meta-analysis only studies in which he had participated and in which there was an appropriate control group. The fraternal birth order effect has also been demonstrated in a number of other studies (Bogaert, 2003; Poasa et al., 2004; Purcell et al., 2000; Zucker and

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Blanchard, 2003; Zucker et al., 1997), including six by investigators working independently of Blanchard and his colleagues (Camperio-Ciani et al., 2004; Green, 2000; King et al., 2005; Rahman, 2005; Robinson and Manning, 2000; Williams et al., 2000). One methodologically similar study (Rahman et al., 2004) did not confirm the effect, perhaps because of inadequate statistical power. The bulk of studies outside Blanchard's (2004) meta-analysis, therefore, bolster the conclusion that the fraternal birth order effect is a reliable one.

Blanchard and Bogaert (1996) hypothesized that the fraternal birth order effect reflects the progressive immunization of some mothers to male-specific antigens by each succeeding male fetus and the concomitantly increasing effects of anti-male antibodies on the sexual differentiation of the brain in each succeeding male fetus. This notion has been called the *maternal immune hypothesis*. In later articles (Blanchard and Klassen, 1997; Blanchard, 2004), Blanchard speculated on the mechanisms by which anti-male antibodies might block full masculinization of the fetal brain, for example, by binding to, and thus inactivating, male-specific molecules located on the surface of fetal brain cells. The recent finding that biological brothers increase the odds of homosexuality in later-born males, even if they were reared in different households, whereas stepbrothers or adoptive brothers have no effect on sexual orientation (Bogaert, 2005) reinforces the notion that the fraternal birth order effect, whatever its precise mechanism, relates to changes in the uterine environment.

A meta-analysis by Lalumière et al. (2000) has established hand preference as another reliable correlate of sexual orientation. That study was carried out to resolve the conflicting conclusions that had been produced by narrative reviews of the relation between handedness and homosexuality. Lalumière et al. computed the rates of non-right-handedness (i.e., preferential use of the left hand, or equal use of both hands, in common tasks) in 20 comparisons of homosexual and heterosexual men. The odds of non-right-handedness were 34% higher for homosexual than for heterosexual men.

Lalumière et al. considered several possible explanations for why homosexual men show an excess of non-right-handedness despite that non-right-handedness is associated with masculinization (Oldfield, 1971) and that male homosexuality is commonly associated with undermasculinization (e.g., Bailey and Zucker, 1995). One explanation was developmental instability: a compromised ability to compensate for perturbations of development. According to this theory, homosexuality and non-right-handedness co-occur in the same individuals because susceptibility to one perturbation implies susceptibility to others. Lalumière et al. (2000) also considered Geschwind and Galaburda's (1985) modification of Dörner's (1972) prenatal androgen hypothesis: homosexual men are exposed to elevated levels of testosterone during some developmental periods in utero but to reduced levels during others. According to Geschwind and Galaburda, elevated testosterone occurs during a critical period for the development of handedness, and reduced testosterone occurs during a critical period for sexual orientation. An alternate formulation of the prenatal androgen hypothesis was suggested by Lindesay (1987): that homosexuality results from elevated levels–and not from reduced levels–of testosterone, and that elevations in testosterone in utero increase the probability both of homosexuality and of non-right-handedness.

Research published after the Lalumière et al. meta-analysis has continued the pattern of inconsistent results from individual studies, with the preponderance of evidence for higher non-right-handedness in homosexual men. Mustanski et al. (2002a) found very similar rates of non-right-handedness for homosexual and heterosexual men, whereas Lippa (2003) found that the odds of non-right-handedness were 82% higher for homosexual men. Zucker et al. (2001) found higher rates of non-right-handedness in boys with gender identity disorder than in control boys; the former group may, for present purposes, be considered a subtype of homosexual males (see Bailey and Zucker, 1995). The relation between handedness and sexual orientation may therefore also be regarded as reliable.

The specific objective of this study was to determine whether fraternal birth order and hand preference interact in their effects on sexual orientation. This question might be stated more concretely in several ways. For example, do older brothers have a greater, lesser, or equal effect on sexual orientation in right-handed and non-right-handed men? The study required a large number of subjects in order to obtain a sufficient number of men in the rarest category: non-right-handed homosexuals. The present authors therefore pooled their data from several studies that happened to include the variables needed for this analysis.

Method

Subjects

The all-male subjects comprised 1774 right-handed heterosexuals, 287 non-right-handed heterosexuals, 928 right-handed homosexuals, and 157 non-right-handed homosexuals. These came from five extremely diverse samples, here called Ellis, Breedlove, Blanchard, Bogaert (Non-biological Families), and Bogaert (Other). These samples represent a mixture of archival data from published studies, unpublished data from studies currently in preparation, and data retrieved specifically for the present study. The samples will be described separately. Each of the samples was collected with approval from the original investigator's institutional research review board. The sizes and demographics of the samples are presented in Table 1.

In this article, we use the word *subject* rather than *participant*, for two reasons: (a) in many cases, the person who actually participated in the study was not the subject but instead his mother, and (b) it is confusing, in the case of re-analyzed archival data, to use language implying that the subjects were recruited to participate in the later study.

Ellis

A detailed description of this sample is given in Ellis and Blanchard (2001), among other places. The sample was collected to investigate numerous potential prenatal and perinatal influences on adult human behavior. The homosexual subjects were university students and sons of P-FLAG members (Parents and Friends of Lesbians and Gays). The heterosexual subjects were university students. The respondents were recruited through numerous universities and P-FLAG chapters in the USA and Canada from 1988 to 1997. Respondents were not given any reward for participating.

Table 1
Number of homosexual and heterosexual men, age, education, and race for subjects from the five original samples

Sample	*N*	Age (mean and standard deviation)	Education (median)	Race (% White)
Ellis [a]				
Homosexual	168	31.88 (7.93)	15.5 years completed	98
Heterosexual	915	21.89 (4.38)	14.0 years completed	95
Breedlove				
Homosexual	278	40.18 (11.38)	Not available	Not available
Heterosexual	104	41.51 (14.72)	Not available	Not available
Blanchard				
Homosexual	92	41.24 (13.63)	High school grad.	89
Heterosexual	672	38.68 (13.31)	High school grad.	75
Bogaert (Non-biological families)				
Homosexual	280	40.00 (9.67)	Some postsecondary	78
Heterosexual	222	37.55 (11.41)	Some postsecondary	72
Bogaert (Other)				
Homosexual	267	35.74 (12.42)	Some postsecondary	85
Heterosexual	148	20.82 (3.94)	Some university	84

[a] For Ellis's sample, *N* and Age refer to the subjects. Education and race describe the educational level and race/ethnicity of the subjects' mothers.

Breedlove

The original study, which investigated the relations among second-to-fourth finger length ratio, birth order, and sexual orientation, was reported by Williams et al. (2000). The subjects were adults who were approached at public street fairs in the San Francisco area during 1999, and who were offered lottery "scratcher" tickets for their participation in that study.

Blanchard

This sample was retrieved specifically for the present study from a cumulative database used in an ongoing neuropsychological research program (e.g., Cantor et al., 2004, 2005). The subjects were patients referred during the years 2000 to 2004 to a hospital unit in Toronto, Ontario, Canada, for clinical assessment of their sexual feelings or behaviors. The subjects were asked, after completion of their assessments, for permission to use their test data in research studies; they were not offered any payment or other incentive in return for this.

Bogaert (Non-biological Families)

These data were collected to compare biological with non-biological older brothers in the prediction of sexual orientation (Bogaert, 2005). The subjects were men (e.g., adoptees) who had been reared in environments other than intact biological nuclear families. These were recruited in 2001–2004 through targeted newspaper advertisements in various Canadian cities. Subjects were paid $20 (Canadian) for their participation.

Bogaert (Other)

This sample comprised three subsamples. The primary purpose of two was to investigate variables that predict homophobia in heterosexual men (Bogaert, 2000, 2001), and that of the third was to investigate variables related to gay men's sexual development and health (Hafer et al., 2001). The heterosexual subjects were students at Brock University (St. Catharines, Ontario, Canada), who participated for Introductory Psychology course credit in 2000 and 2001. The homosexual subjects were mostly community adults who were recruited in 1999 through newspaper advertisements and who were paid $20 (Canadian) for their participation.

Materials and procedure

Ellis

Paired self-administered questionnaires (for mothers and children) were distributed in university classes; the mothers' questionnaire was distributed through P-FLAG chapters without the accompanying children's questionnaires. Thus, the P-FLAG mothers provided all information about their offspring. The mothers of university students provided all information except the subject's sexual orientation, which was taken from the questionnaire completed by the subject.

Parallel items in the mothers' and children's questionnaires asked if the subject (son or self) was heterosexual, bisexual, or homosexual. In the present study, as in Ellis and Blanchard (2001), the bisexual subjects were included with the homosexual ones. One item in the mothers' questionnaire asked the respondent to rate the subject's handedness on a 5-point scale. Subjects described by their mothers as extremely or generally right-handed were classed as right-handed for this study; those described as ambidextrous, generally left-handed, or extremely left-handed were classed as non-right-handed. Information on the subject's sibship came from a section of the mothers' questionnaire in which the respondent was requested to list all her known pregnancies. Maternal half siblings were counted the same as full siblings.

Breedlove

The subjects completed a self-administered questionnaire as part of their examination. One questionnaire item asked the subject how he identified himself with regard to sexual orientation. Subjects who identified themselves as exclusively or predominantly heterosexual were classified as heterosexual in this study (as in Williams et al., 2000); subjects who identified themselves as bisexual, predominantly homosexual, or exclusively homosexual were classed as homosexual. Another item asked the subject which hand he usually used for writing. Subjects who indicated the right hand were classified as right-handed for the present study; subjects who indicated the left hand or both hands were classified as non-right-handed. Sibship information came from questionnaire items that asked the subject how many male and how many female babies his biological mother had carried before him; information on younger siblings was not collected. Full siblings were not differentiated from maternal half siblings. Subjects were not asked their degree of certainty that they knew of all children born to their mother.

Blanchard

The information used in this study came from variety of sources: (a) a structured sexual history interview, which covered the patient's self-reported erotic preferences as well as his history of criminal and non-criminal sexual behaviors, (b) clinical and legal documents pertaining to the patient's charges and convictions for sexual offenses, (c) a self-administered questionnaire that included the patient's personal and family demographics, (d) a structured interview that accompanied his neuropsychological testing and that included a standard handedness inventory, and (e) phallometric testing. Phallometric testing is a psychophysiological method for the assessment of erotic preferences in human males. In this procedure, a man's penile blood volume changes are monitored as he experiences a standard, prerecorded set of potentially erotic stimuli. The phallometric data used in the present study came from a test described in detail by Blanchard et al. (2001); the stimuli were depictions of prepubescent, pubescent, and physically mature males and females. The examinee's penile responses to the various gender–age categories were ipsatized by *z*-scoring, that is, standardized within subjects.

The patient's sexual orientation was classified as heterosexual or homosexual while ignoring the age of the males or females he found most attractive. Reasons for ignoring age-preference have been presented elsewhere (e.g., Blanchard et al., 2000; Bogaert et al., 1997). Classification was accomplished by sieving the patient through a fixed sequence of diagnostic criteria. The first criterion was based on his history of sexual offending. If the patient's maximum number of victims in any one category of males (prepubescent, pubescent, teenaged, or adult) was greater than his maximum number of victims in any one category of females, and if that maximum number was greater than or equal to four victims, then the patient was classified as homosexual. If the patient satisfied the reverse criterion (female victims greater then male victims and greater than or equal to four), then he was classified as

heterosexual. If the patient satisfied neither sexual-offense criterion, then he was evaluated according to his phallometric test results. If the patient's penile response to any age-category of males exceeded his maximum response to any age-category of females by 0.25 *z*-units, then he was classified as homosexual. If he satisfied the reverse criterion (maximum penile response to females), he was classified as heterosexual. If he satisfied neither phallometric criterion, he was next evaluated according to his (qualified) self-report. If the patient stated that his sexual attraction to any age-category of males was greater than his strongest attraction to any age-category of females, then he was classified as homosexual, provided that he had no sexual offenses against females of any age. If he met the reverse criterion, he was classified as heterosexual. The reason that these patients' sexual orientations were not classified on the basis of their self-reports alone, as was done with the other samples, is the well-known unreliability of self-reported erotic interests in sexual offenders (see, for example, Blanchard et al., 2001).

As in most of the other samples, the assessment of handedness was based solely on writing hand. If the patient told the interviewer that he wrote with his right hand, he was classified as right-handed. If he said the left hand or both hands, he was classified as non-right-handed. Items on the personal and family demographics questionnaire asked the patient how many boys and girls his mother delivered before and after she gave birth to him and whether he felt sure that he knew of all children delivered by his mother. A subject was excluded if his mother had any children by any man other than the subject's own father—the usual practice in the first author's laboratory when numbers of subjects permit (e.g., Blanchard and Bogaert, 1996). Thus, "siblings" for this sample meant "full siblings".

Bogaert (Non-biological Families)

Subjects completed and mailed in a self-administered questionnaire. For the present study, the subject's sexual orientation was classified on the basis of two items. One asked the subject to rate his sexual behavior, and the other to rate his sexual thoughts and feelings, on identical 7-point scales. The end-points of these scales were labeled "exclusively heterosexual" and "exclusively homosexual," and the mid-point was labeled "equally homosexual and heterosexual." Scores on these items were averaged. Subjects whose averaged scores fell in the range from "exclusively homosexual" to "equally homosexual and heterosexual" were classified as homosexual; the remainder was classified as heterosexual. Another item asked the subject to indicate his writing-hand preference on a 5-point scale. Subjects who indicated that they always or usually wrote with their right hands were classified as right-handed; those who indicated that they wrote with both hands or that they usually or always used the left were classified as non-right-handed. Sibship information was collected with a variety of items. The present study used the number of biological siblings known to the subject (whether he ever resided with them or not). Maternal half-siblings were not differentiated from full siblings.

Bogaert (Other)

The subjects completed self-administered questionnaires that included the items described in the previous paragraph. In the case of the paid sample, the questionnaires were mailed in to the investigators. Quantification of sexual orientation, handedness, and sibship composition was similar to that for the other Bogaert sample.

Results

The data analysis was conducted from two different perspectives: one taking sexual orientation as the dependent variable and one taking handedness as the dependent variable. This was done partly because it facilitated comparison of the present results with those of earlier studies, which have varied in their designation of the dependent variable, depending on their focus. It was also done because interaction effects–the topic of the present research–can be viewed from different perspectives, and the conclusions suggested by one view are not necessarily redundant with the conclusions suggested by another.

Sexual orientation as the dependent variable

Most recent statistical analyses of sexual orientation and fraternal birth order have treated sexual orientation as the dependent variable (e.g., Bogaert, 2005). This approach follows directly from the assumed causal model–a man's number of older brothers might influence his sexual orientation, but not vice versa–and it also enables quantitative estimation of the impact of each older brother. The present question, "Do older brothers have the same effect on sexual orientation in right-handed and non-right-handed men," was therefore investigated in a series of logistic regression analyses, with sexual orientation, coded 0 for heterosexual and 1 for homosexual, treated as the criterion (i.e., dependent) variable.

The first analysis used only one predictor (i.e., independent) variable: the subject's original sample (hereafter, *source*). Source was deviation-coded, with Ellis's sample as the reference category. In this context, the choice of deviation coding (weights = −1, 0, or 1) for this categorical variable was arbitrary, as was the designation of Ellis's sample as the reference category (the category with weight = −1).

The first analysis was actually just a preliminary step in graphing the statistical relations of primary interest. Its sole purpose was to control for between-samples differences–specifically, the large differences in the proportion of homosexual subjects–in the visual representation of the main findings, and thus to partly parallel our control for these differences in the statistical analysis of those findings. To this end, sexual orientation was regressed on source, and the standardized differences between the observed and expected probabilities of homosexuality were saved as a new variable, the residual probability of homosexuality.

Fig. 1 shows the residual probability of homosexuality as a function of handedness and number of older brothers. Negative values along the ordinate denote probabilities of homosexuality lower than the mean for all subjects, and positive values denote probabilities higher than the mean. The figure shows the usual association between increasing numbers of older brothers and increasing probabilities of homosexuality, but only for right-handed men. For non-right-handed men, the curve relating older brothers to homosexuality appears quite different, perhaps even opposite. It should be noted that the capping of the older brothers variable at "three or more" was done solely for the purpose of tidying the graphical display. In all statistical analyses, numbers of older brothers and older sisters were analyzed exactly as reported.

Analogous data are shown in Fig. 2 for number of older sisters. There is, again as usual, little evidence of any association between a man's number of older sisters and his likelihood of homosexuality. The curve for right-handers is virtually flat, and the curve for non-right-handers does not depart markedly from that.

The second logistic regression analysis investigated whether regression lines fitted to the data shown in the figures would in fact differ significantly in slope between right-handed and non-right-handed men. There were six predictors, four of which represented main effects: older brothers, older sisters, source,

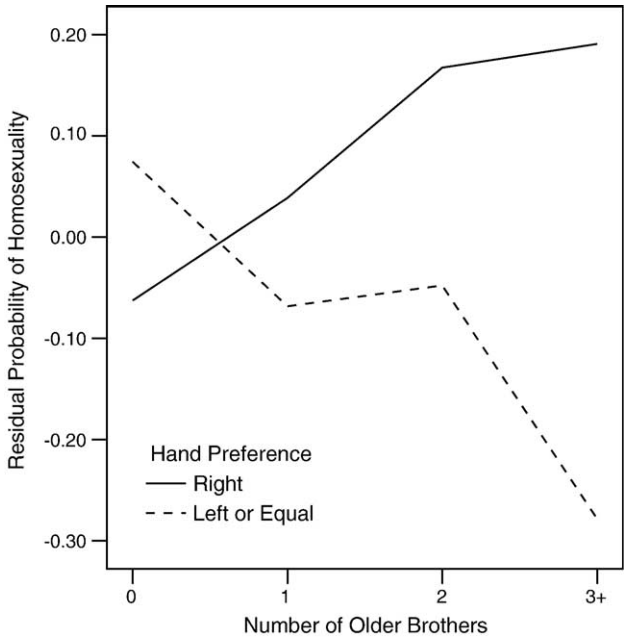

Fig. 1. Standardized residual probability of homosexuality as a function of older brothers and handedness. Higher values indicate greater probabilities of homosexuality. See text for explanation.

and handedness. Number of older brothers and number of older sisters were treated as continuous variables. Handedness (right or non-right) and source (the five samples of origin) were treated as categorical variables. These were deviation-coded; the reference categories were right-handed for the handedness variable and Ellis's sample for the source variable. The other two predictors were the product of handedness and older brothers and the product of handedness and older sisters. These terms carried the interactions of handedness with older brothers and older sisters, respectively. The results are shown in Table 2. The results confirmed that handedness interacts significantly with older brothers (see Fig. 1) but not with older sisters.

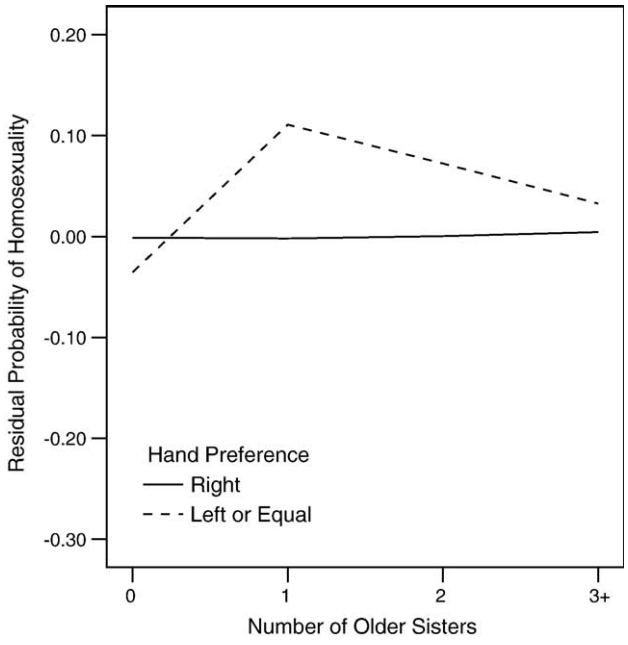

Fig. 2. Standardized residual probability of homosexuality as a function of older sisters and handedness.

Table 2 shows that the main effects for older brothers and older sisters were not significant when the full group of subjects was used and the terms for the interactions of handedness with older brothers and older sisters were included in the model. The third and fourth analyses tested whether the relations between older brothers and sexual orientation (Fig. 1) would be statistically significant within groups who had the same hand preference.

The third analysis was carried out on the 2702 right-handers only. The predictors were source, older brothers, and older sisters. The results (Table 3) indicate a significant odds ratio of 1.24 for older brothers, which means that each older brother increased the odds of homosexuality by about 24%. The relation between older sisters and homosexuality was not statistically significant and was not even in the same direction. It must be stressed that this result cannot be considered a replication because the combined sample includes previously published data. The odds ratio for older brothers (1.24) was a little lower than usual. This may relate to the considerable heterogeneity of the subjects or to the fact that we did not fully control for family size (younger brothers and younger sisters were not available for all subjects and could not be included in the analysis). It does not appear to be related specifically to the inclusion of Blanchard's sample (patients rather than community volunteers) because the same odds ratio computed on right-handed subjects from that sample alone was virtually identical: 1.25.

The fourth analysis was similar to the third one, except that it was carried out on the 444 non-right-handers only. The results are shown in Table 4. Both the relation between sexual orientation and older brothers and the relation between sexual orientation and older sisters were opposite in direction to those observed among the right-handers; in this group, older brothers lowered the odds of homosexuality and older sisters raised them. However, neither of these relations was statistically significant.

In summary, we could reject the hypothesis that the slope of the line relating older brothers to sexual orientation is zero for right-handed subjects, and we could reject the hypothesis that the slope is the same for right-handed and non-right-handed

Table 2
Logistic regression of sexual orientation on source, number of older brothers, number of older sisters, and hand preference, using all subjects

Predictor	*B*	SE	Wald	*df*	*P*	e^B
Source			724.44	4	<0.0001	
Older brothers	0.02	0.07	0.13	1	0.72	1.02
Older sisters	0.03	0.08	0.17	1	0.68	1.03
Handedness	0.07	0.08	0.84	1	0.36	1.08
Handedness by older brothers	−0.19	0.06	8.47	1	0.004	0.83
Handedness by older sisters	0.12	0.08	2.42	1	0.12	1.13

Note. Contrasts for levels of the *source* variable are not presented because the differences in the proportion of homosexual subjects in the five samples are not "findings" and have no importance in themselves.

Table 3
Logistic regression of sexual orientation on source, number of older brothers, and number of older sisters, using right-handed subjects

Predictor	*B*	SE	Wald	*df*	*P*	e^B
Source			623.18	4	<0.0001	
Older brothers	0.21	0.05	18.93	1	<0.0001	1.24
Older sisters	−0.09	0.05	3.05	1	0.08	0.92

subjects. We could not reject the hypothesis that the slope is zero for the non-right-handed subjects, despite the negative-tending curve suggested by Fig. 1.

The foregoing findings (especially Fig. 1) prompted the hypothesis that the etiological factors associated with non-right-handedness and fraternal birth order might cancel each other out. This hypothesis generated the testable prediction that the odds of homosexuality among non-right-handed men with older brothers will be similar to the odds among right-handed men without older brothers. The data, re-cast in a form that corresponded to this question, are shown in Fig. 3. The raw data appeared consistent with the prediction.

The hypothesis was formally tested in the logistic regression analysis reported in Table 5. A new variable, handedness–brothers, was created for this analysis. This variable represented the subject's assignment to one of four groups, according to his hand preference and his number of older brothers: (a) no older brothers and right-handed (n = 1630), (b) no older brothers and non-right-handed (n = 248), (c) one or more older brothers and right-handed (n = 1072), and (d) one or more older brothers and non-right-handed (n = 196). Handedness–brothers was indicator-coded, with the first group (no older brothers and right-handed) as the reference category.

The results were similar with and without source and number of older sisters added to the regression equation as control variables. We will therefore comment only on the results with the control variables (bottom panel of Table 5). The odds of homosexuality were 41% higher for men who had a non-right hand preference, and 50% higher for men who had older brothers, relative to men with neither of these features. As we predicted, however, the odds for men with both features were similar to the odds for men with neither.

Handedness as the dependent variable

All previous studies of handedness and sexual orientation have treated handedness as the dependent variable and compared rates of non-right-handedness in heterosexual and homosexual men (See Lalumière et al., 2000). Our second set of analyses estimated rates of non-right-handedness that could be compared directly with those calculated in previous studies and investigated how differences in fraternal birth order affected these rates.

Table 4
Logistic regression of sexual orientation on source, number of older brothers, and number of older sisters, using non-right-handed subjects

Predictor	*B*	SE	Wald	*df*	*P*	e^B
Source			102.61	4	<0.0001	
Older brothers	−0.12	0.12	0.97	1	0.32	0.89
Older sisters	0.15	0.14	1.09	1	0.30	1.16

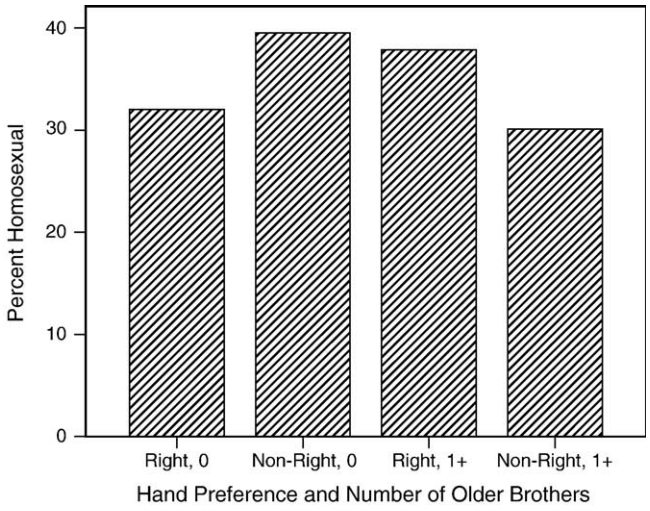

Fig. 3. Percentage of homosexual subjects in each of four groups: right-handed and no older brothers (Right, 0), non-right-handed and no older brothers (Non-Right, 0), right-handed and one or more older brothers (Right, 1+), and non-right-handed and one or more older brothers (Non-Right, 1+).

A preliminary comparison of the five samples showed that the rates of non-right-handedness varied little among them: 13% to 16%. The differences in rates were not statistically significant, likelihood ratio $\chi^2(4, N = 3146) = 1.59$, $P > 0.80$.

The first analysis was a straightforward methodological replication of previous studies. This analysis, which used all subjects, found that the rates of non-right-handedness in the

Table 5
Logistic regression of sexual orientation on subjects grouped by hand preference and existence of any older brothers (handedness–brothers), source, and number of older sisters, using all subjects

Predictor	*B*	SE	Wald	*df*	*P*	e^B
Model 1						
Group (handedness–brothers)			14.22	3	0.003	
Right-handed, 0 older brothers vs.						
Non-right-handed, 0 older brothers	0.33	0.14	5.43	1	0.02	1.39
Right-handed, ≥1 older brothers	0.26	0.08	9.79	1	0.002	1.29
Non-right-handed, ≥1 older brothers	−0.09	0.16	0.30	1	0.59	0.91
Model 2						
Group (handedness–brothers)			19.16	3	0.0003	
Right-handed, 0 older brothers vs.						
Non-right-handed, 0 older brothers	0.34	0.16	4.37	1	0.04	1.41
Right-handed, ≥1 older brothers	0.41	0.10	15.88	1	<0.0001	1.50
Non-right-handed, ≥1 older brothers	−0.06	0.19	0.11	1	0.75	0.94
Source			725.24	4	<0.0001	
Older sisters	−0.04	0.05	0.62	1	0.43	0.96

homosexual men (14%) and the heterosexual men (14%) were not significantly different, $\chi^2(1, N = 3146) = 0.17$, $P > 0.60$. The interaction detected in the first phase of our data analysis, however, suggested that one might find handedness differences between homosexual and heterosexual men if one examined subjects with older brothers and subjects without older brothers separately. This proved so. There were 620 homosexual and 1258 heterosexual men who had no older brothers. The rate of non-right-handedness was 16% for the homosexuals and 12% for the heterosexuals. This result, expressed differently, means that the homosexual subjects had 39% greater odds of being non-right-handed. A χ^2 test showed that the difference between groups was statistically significant, $\chi^2(1, N = 1878) = 5.33$, $P = 0.02$.

Contrary results were found for the 465 homosexual and 803 heterosexual men who had one or more older brothers. For these men, the rate of non-right-handedness was 13% for the homosexuals and 17% for the heterosexuals. This result means that the homosexual subjects had 29% lesser odds of being non-right-handed. The difference between these groups was also statistically significant, $\chi^2(1, N = 1268) = 4.41$, $P = 0.04$. Neither of the foregoing findings was substantially altered when we examined the relation between handedness and sexual orientation in a logistic regression set-up and controlled for the variables, source, and number of older sisters.

The last analysis focused on the question: do older brothers influence handedness itself, besides interacting with handedness to influence sexual orientation? The question was addressed with a logistic regression analysis similar to that presented in Table 2, with the exception that the roles of sexual orientation and hand preference were reversed. In this analysis, hand preference, coded 0 for right and 1 for left or equal, was the criterion variable. Sexual orientation took the place of handedness among the predictors. Sexual orientation was deviation-coded, with the heterosexuals as the reference category. The analysis was carried out on all 3146 subjects.

The results (Table 6) did not support the notion that older brothers affect handedness itself. There were only two statistically significant findings. One was the sexual orientation by older brothers interaction. This is simply the handedness by older brothers interaction (Table 2), viewed from a different perspective. The other significant finding was the main effect for older sisters: each older sister decreased the odds of non-right-handedness by 15%.

Table 6
Logistic regression of hand preference on source, number of older brothers, number of older sisters, and sexual orientation, using all subjects

Predictor	*B*	SE	Wald	*df*	*P*	e^B
Source			1.20	4	0.88	
Older brothers	0.02	0.06	0.15	1	0.70	1.02
Older sisters	−0.17	0.07	6.49	1	0.01	0.85
Sexual orientation	0.04	0.07	0.30	1	0.59	1.04
Sexual orientation by older brothers	−0.13	0.06	5.57	1	0.02	0.88
Sexual orientation by older sisters	0.11	0.06	2.99	1	0.08	1.12

Discussion

The study produced three main findings. All argue that handedness and fraternal birth order interact with regard to sexual orientation. First, the positive correlation between homosexuality and greater numbers of older brothers appears to hold only for right-handed males. The best evidence at this time suggests that the correlation is zero for non-right-handed males. Second, the relative rates of non-right-handedness in homosexual and heterosexual men depend on their numbers of older brothers. Among men with no older brothers, homosexuals are more likely to be non-right-handed than heterosexuals; among men with one or more older brothers, homosexuals are less likely to be non-right-handed than heterosexuals. Third, the odds of homosexuality are higher for men who have a non-right hand preference or who have older brothers, relative to men with neither of these features, but the odds for men with both features are similar to the odds for men with neither. It goes without saying that these findings should be regarded as tentative unless and until they are confirmed in additional samples. In the meantime, one can consider how our data might be explained, and how they might explain the data of others.

The three main findings may be interpreted as follows: some factor associated with non-right-handedness increases the odds of homosexuality in first male births. This same factor, however, prevents older brothers from increasing the odds of homosexuality in later male births. If that interpretation is correct, the problem becomes one of identifying the postulated factor. One possible candidate is fetal testosterone.

As stated in the Introduction, Lindesay (1987) hypothesized that males exposed to higher levels of fetal testosterone are more likely to become non-right-handed and to become homosexual. This hypothesis was advanced to explain the correlation between non-right-handedness and homosexuality, but it has also been used to account for other findings (Alias, 2004; Bogaert and Hershberger, 1999; McFadden and Champlin, 2000). A variant form of this hypothesis, which could explain much the same data, would be that males who are more sensitive to fetal testosterone are more likely to be non-right-handed and homosexual. In either form, this hypothesis requires the auxiliary proposition that hyperandrogenization of the male fetus may paradoxically produce the same outcome as hypoandrogenization: atypical sexual differentiation in the fetal brain and a future preference for male rather than female sexual partners. Such paradoxical effects have never been demonstrated directly in humans, but some animal research suggests that they may be possible (Baum and Schretlen, 1975; Clark et al., 1996; Diamond et al., 1973; Pollak and Sachs, 1975).

The hyperandrogenization hypothesis can obviously be applied to the present finding that, among men with no older brothers, non-right-handedness is more common in homosexuals than in heterosexuals, because the handedness–homosexuality correlation is one of the findings that it was advanced to explain in the first place. There is no scientific consensus that the hyperandrogenization hypothesis is correct

(e.g., James, 2001), and even the notion that high levels of testosterone produce non-right-handedness has been contested (e.g., Previc, 1994). Our present purpose, however, is not to undertake a general evaluation of the hypothesis but rather to consider whether it could also explain the finding that older brothers do not increase the odds of homosexuality in non-right-handed males.

The hyperandrogenization hypothesis implies that high rates of non-right-handedness may be interpreted as evidence of high concentrations of fetal testosterone, which–in more moderate quantities–masculinizes the brain. The maternal immune hypothesis implies that older brothers may be interpreted as evidence of anti-male antibody, which feminizes the brain. If both factors (hypermasculinization and feminization) are present in the same fetus, they may cancel each other out, yielding the functional equivalent of typical masculinization. Thus, one might expect to find higher rates of homosexuality among men who have a non-right hand preference, or who have older brothers, but not among men who have both. This hypothesis predicts that the rate of homosexuality among non-right-handed men with older brothers should be similar to the rate among right-handed men without older brothers. This prediction proved consistent with our data.

Another possible explanation has no direct precedent in the sexual orientation research literature but is much simpler: the number of non-right-handed homosexuals with older brothers is smaller than expected because the combination of the older brothers factor with the non-right-handedness factor (be it hyperandrogenization, developmental instability, or something else) is toxic enough to lower the probability that the affected fetus will later be available for research. This could happen if the combination lowers the fetus's chances of survival, or if it predisposes the individual to some condition (e.g., mental retardation) that makes him less likely to be sampled than other members of the community.

This alternative explanation is consistent with prior findings that older brothers decrease the birth weight of subsequent male fetuses (Blanchard and Ellis, 2001; Côté et al., 2003), especially prehomosexual male fetuses (Blanchard and Ellis, 2001; Blanchard et al., 2002), and that non-right-handedness also correlates with low birth weight (e.g., O'Callaghan et al., 1987; Powls et al., 1996). Low birth weight is generally disadvantageous for fetal health, and it is associated with lower IQ in fetuses born alive (e.g., Matte et al., 2001). Such findings constitute reason to speculate that the combination of older brothers and non-right-handedness might differentially affect the probability of homosexual males' inclusion in survey research, and that this produced the lower than expected percentage of homosexuals among our non-right-handed subjects with older brothers (Fig. 3).

The alternative explanation of the present data fits more naturally with the developmental instability hypothesis than with the hyperandrogenization hypothesis of the non-right-handedness/homosexuality correlation. The notion of increased vulnerability to environmental perturbation (developmental instability) complements the notion of increased amount of environmental perturbation (maternal immune products). Thus, the male fetus that is either unusually susceptible to environmental perturbation or is exposed to unusually high levels of it will be healthy but with greater odds of homosexuality; the fetus that has both unusual susceptibility and unusually high exposure will have diminished chances of survival or significant later medical or cognitive problems. It should be stressed that the finding that homosexual women have even more elevated rates of non-right-handedness than homosexual men (Lalumière et al., 2000) may or may not have any relevance to this argumentation. It is quite possible that homosexual men manifest increased rates of non-right-handedness for one reason (e.g., developmental instability) and homosexual women manifest the same phenomenon for a completely different reason (e.g., prenatal hormone levels or sensitivities).

Of course, both explanations of the present data, like any other hypotheses that might be advanced right now, are purely conjectural. They are offered largely as a stimulus to further study.

The second main finding–the relative rates of non-right-handedness in homosexual and heterosexual men depend on their numbers of older brothers–may explain the inconsistent results of prior studies on handedness and sexual orientation. According to our results, studies with higher proportions of first-born sons will tend to find higher rates of non-right-handedness in homosexual than in heterosexual men; studies with lower proportions will tend to find equal rates in homosexual and heterosexual men. The proportion of first-born sons (i.e., men with no older brothers) in a sample depends on the mean family size of the sample; and this will likely depend, in turn, on the socioeconomic status of the sample and on the period in which the subjects were born (e.g., during the 1945–1960 baby boom). Thus, seemingly irrelevant demographics of a sample could affect whether the researcher finds a higher proportion of non-right-handed cases in the homosexual group. It should be noted that typical recruiting procedures will rarely produce a sample in which the large majority of men have one or more older brothers, therefore few studies should find that homosexual men have significantly *lower* rates of non-right-handedness than heterosexual men.

The study yielded one incidental finding that requires discussion: in our subjects, older sisters appeared to lower the odds of non-right-handedness in later-born males. Precisely the opposite results were obtained by Lippa (2003), who reported that the percentage of non-right-handed individuals in his male subjects increased with number of older sisters. It is therefore most likely that our findings for sororal birth order and handedness reflect Type I error.

Future research might investigate other differences between right-handed and non-right-handed homosexual men besides fraternal birth order. One example is cognitive abilities, which McCormick and Witelson (1991) found to differ between these groups. Future research on this topic might also include the collection of data on the handedness of subjects' relatives. Such data would permit the

designation of non-right-handed subjects as probably familial (i.e., genetic) vs. probably sporadic (i.e., non-genetic) cases. This could open up other avenues for explaining the present findings, including genetic ones. If, for example, familial non-right-handers are impervious to the effect of older brothers on sexual orientation, whereas sporadic non-right-handers are just as vulnerable as right-handers, this would suggest that familial non-right-handers represent a distinctive genetic subpopulation. If–to give a second example–non-right-handed homosexuals with older brothers are confirmed to be an underrepresented group in survey research, and the "missing" subjects prove to be of the sporadic type, this would tend to favor the previously stated toxic combination hypothesis. That is because sporadic non-right-handedness is generally associated with perturbations of fetal development, and this might be exacerbated by maternal anti-male antibodies stimulated by older brothers.

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