Arch Sex Behav (2007) 36:163–176
DOI 10.1007/s10508-006-9159-7

ORIGINAL PAPER

Birth Order, Sibling Sex Ratio, Handedness, and Sexual Orientation of Male and Female Participants in a BBC Internet Research Project

Ray Blanchard · Richard A. Lippa

Published online: 8 March 2007

Abstract This study investigated the relations among sexual orientation, fraternal birth order (number of older brothers), and hand-preference. The participants were 87,798 men and 71,981 women who took part in a Web-based research project sponsored by the British Broadcasting Corporation (BBC). The results yielded some evidence confirming prior findings that non-right-handedness is associated with homosexuality in men and women, that older brothers increase the odds of homosexuality in men, and that the effect of older brothers on sexual orientation is limited to right-handed men. The evidence was weaker than in previous studies, however, probably because the usual relations among the variables of interest were partially obscured by the effects of other factors. Thus, the homosexual men and women had higher rates of non-right-handedness than their heterosexual counterparts, but the strongest handedness finding for both sexes was a marked tendency for participants who described themselves as ambidextrous also to describe themselves as bisexual. The birth order data were strongly affected by a tendency for the male participants to report an excess of older sisters, and the female participants to report an excess of older brothers. Statistical analyses confirmed that this was an artifact of the parental stopping rule, "Continue having children until you have offspring of both sexes." In subsequent analyses, participants were divided into those who did and did not have younger siblings, on the grounds that the data of the former would be less contaminated by the stopping rule. In the former subsample, the right-handed homo/bisexual males showed the typical high ratio of older brothers to older sisters, whereas the non-right-handed homo/bisexual males did not.

Keywords BBC · Birth order · Demography · Epidemiology · Family size · Handedness · Homosexuality · Immunization · Internet · Sex ratio · Sexual orientation · Stopping rules

R. Blanchard (✉)
Centre for Addiction and Mental Health,
Law and Mental Health Program,
250 College Street, Toronto, Ontario M5T 1R8, Canada
e-mail: Ray_Blanchard@camh.net

R. Blanchard
Department of Psychiatry, University of Toronto,
Toronto, Ontario, Canada

R. A. Lippa
Department of Psychology, California State University,
Fullerton, California

Introduction

Two findings have repeatedly emerged in epidemiological studies of sexual orientation: (1) older brothers increase the odds of homosexuality in males, and (2) homosexuality is associated with non-right-handedness in both males and females. The first phenomenon has been called the *fraternal birth order effect*. Older brothers—but not older sisters, younger brothers, or younger sisters—are associated with sexual orientation in males, and no class of siblings is associated with sexual orientation in females (e.g., Blanchard, 2004; Camperio-Ciani, Corna, & Capiluppi, 2004; Green, 2000; King et al., 2005; Rahman, 2005; Robinson & Manning, 2000; Williams et al., 2000).

Recent data have further shown 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, 2006). These observations argue that the fraternal birth order effect, whatever its precise mechanism of action,

relates to changes in the uterine environment. 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. In subsequent articles (Blanchard, 2004; Blanchard & Klassen, 1997), the first author 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.

As noted at the start, the second well-established epidemiological finding is a correlation between homosexuality and non-right-handedness (i.e., preferential use of the left hand, or equal use of both hands, in common tasks). Meta-analysis has shown that homosexual women report higher rates of non-right-handedness than heterosexual women, and homosexual men report higher rates of non-right-handedness than heterosexual men (Lalumière, Blanchard, & Zucker, 2000). The meta-analytic results indicated that the magnitude of the effect is greater in women than in men, but individual studies have varied in this regard (cf. Lippa, 2003; Mustanski, Bailey, & Kaspar, 2002).

Lalumière et al. discussed several alternative explanations for why non-right-handedness is associated with homosexuality in both men and women. One possibility they suggested 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. Other investigators (reviewed by Blanchard, Cantor, Bogaert, Breedlove, & Ellis, 2006; Lalumière et al., 2000) have attempted to explain the findings in terms of prenatal hormone levels.

Blanchard et al. (2006) investigated whether fraternal birth order and hand-preference interact in their effects on sexual orientation. Their findings suggested that the effect of older brothers on sexual orientation is limited to right-handed males—that older brothers do not increase the odds of homosexuality in left-handed or ambidextrous males. Opportunities to replicate the study by Blanchard et al. (2006) using existing data sets are limited because of the large sample size required to yield a sufficient number of non-right-handed homosexual males. The present study took advantage of a rare opportunity to investigate the existence of a handedness × birth order interaction in a very large sample of homosexual and heterosexual men. It also undertook to confirm the previous findings that homosexuality is associated with non-right-handedness in males and in females.

Method

Participants

From February through May 2005, the British Broadcasting Corporation (BBC) conducted an Internet research survey in conjunction with their BBC One television documentary, "Secrets of the Sexes" (see Reimers, 2007). The project was designed in consultation with several researchers in the behavioral and biological sciences, including the second author of this article. The overarching theme of the research was human sex differences in cognition, motivation, personality, and sexuality. Portions of the survey included questions that assessed sexual orientation and handedness. The survey was advertised on the BBC Website, and participants responded via computer. People who logged in to the survey Website could complete a variety of psychological tests and questionnaires, which were arranged in a series of modules. A total of 462,859 people worldwide responded in part or in full, with 255,114 responding to at least some items in every module of the research. We considered only the latter subgroup. The present study was based on questionnaire items in the BBC data pertaining to sexual orientation, hand-preference, and sibship composition.

Measures

The BBC project did not focus primarily on hand-preference or sibship composition—let alone their interaction regarding sexual orientation, which was then unknown to the BBC's scientific consultants. The data collected on these variables were therefore minimal.

Hand-preference was assessed with the question, "Which is your natural writing hand?" The response options were five degrees of preference from left to right. The response options were represented by a horizontal row of five buttons, with the leftmost button labeled "Left" and the rightmost button labeled "Right." Participants indicated their preference by mouse-clicking on one of these buttons.

Sibship composition was assessed with four items. The first read: "How many children did your mother give birth to? (This includes all children ie yourself and half siblings)." Participants entered their answers from a drop-down menu, which offered 11 options: the numbers 1–9, ≥10, and "Unknown." The second item read: "What's your order in the family? (Not including step-brothers or sisters)." The drop-down menu offered 10 response options, representing every birth rank from "First born" to "Tenth (or more) born." The third sibship item was: "How many older biological brothers do you have? (including half siblings)." The menu offered 12 options: the numbers 0–9, ≥10, and "Not applicable." The fourth item—"How many older biological sisters do you

have? (including half siblings)"—offered the same response options as the brothers item. The foregoing items could be used to calculate participants' total numbers of younger siblings, but it was not possible to calculate numbers of younger brothers and younger sisters separately.

Sexual orientation was assessed with three items. The first item asked: "What is your sexual orientation?" Participants answered from a drop-down menu, the choices being "Heterosexual (straight)," "Homosexual (gay/lesbian)," and "Bisexual." The second and third items asked: "How sexually attracted are you to men," and "How sexually attracted are you to women." The response options for each item represented seven degrees of preference, with the end-points labeled "Not at all" and "Very."

Participants reported their education by mouse-clicking one of six ordered options on a drop-down menu. For our statistical purposes, the education levels were quantified with the following values: primary or grammar school (1), secondary or high school (2), technical or vocational college (3), other college (4), university (5), postgraduate or professional degree (6).

Procedure

To be included in the analyses that follow, a participant needed nonmissing values on 10 variables: sex, age, the 4 sibship variables, the 3 sexual orientation variables, and handedness. Of the initial 255,114 participants, only 206,097 had valid values for all 10.

Participants were screened according to the consistency of their responses to the three sexual orientation items. Consistency was determined as follows: If a male participant described himself as "Heterosexual (straight)" on the first item, then he had to report more attraction to women than to men on the other items. Conversely, if a male described himself as "Homosexual (gay)" on the first item, then he had to report more attraction to men than to women on the other items. If a male participant described himself as "Bisexual" on the first item, then he had to report at least some attraction (i.e., more than "Not at all") both to men and to women. The same rules were applied, *mutatis mutandis*, to the female participants. There were 3,375 persons who responded inconsistently to the sexual orientation items, leaving 202,722 for further evaluation.

Participants were next screened according to the consistency and informativeness of their responses to the four sibship composition items. These were determined according to three rules: (1) The number of children born to the participant's mother was not reported as "Unknown." (2) The participant's reported birth order had to equal the number of older brothers plus the number of older sisters plus one. (Example: If a female participant indicated that she had two older brothers and one older sister, then she had to describe herself as "Fourth born.") (3) The participant's reported birth order had to be less than or equal to the number of children born to the participant's mother. (Example: If a female participant described herself as "Fourth born," then she had to report that her mother had at least four children.) There were 42,889 persons who failed one or more of the consistency criteria; the largest number of these (41,728) failed the second criterion (i.e., their self-reported birth order did not equal their number of older brothers plus older sisters plus one). Examination of the cases who failed the consistency criteria did not suggest any single, major explanation for these errors—Reimers (2007) suggested that many participants may have misread the sibship composition items. The number of participants who remained after their exclusion was 159,833.

The last screening procedure, which concerned age, depended somewhat on judgment rather than on logic alone. The range of reported ages in the initial sample of 255,114 cases was from 0–99 years. There were 115 participants who reported their ages as less than 6 years, and 67 participants who reported their age as 99 years. Only 12 others reported ages between 91–98 years, so the supposed 99-year-olds formed a distinct "bump" in the age distribution. Persons who reported preschool ages were obviously making accidental errors or intentional attempts to spoil the survey. We inclined to the view that these errors were more likely intentional and mischievous, because age was entered from the keyboard into an empty field, not by mouse-clicking on a drop-down menu, and a failure to enter any age would put a missing value into the database, not a zero or some other number.

In the previously screened group of 159,833, the number of cases with suspicious or impossible ages was reduced, but not to zero. We therefore excluded the remaining supposed preschoolers along with any other participants under the age of 18, on the grounds that persons under that age might not have a full awareness of their sexual orientation (or even have understood the relevant questions). We excluded participants with the highest reported ages on the grounds that such ages were also relatively likely to be intentionally or unintentionally false. We used a conservative cutting score of 81 years for this purpose, on the view that it was better to eliminate a few valid cases than to include potentially malicious ones. Thus, all participants whose data were retained were between the ages of 18 and 80, inclusive. After we excluded the 54 persons outside this age range, 159,779 participants remained for the study, representing 63% of the initial respondents. There were 87,798 males and 71,981 females.

Results

Sample demographics

The male participants comprised 79,519 heterosexuals, 3,663 bisexuals, and 4,616 homosexuals. The mean ages of

these groups were 32.50 ($SD = 11.28$), 32.53 ($SD = 11.75$), and 32.00 ($SD = 10.12$) years, respectively. A one-way analysis of variance (ANOVA) showed that the mean differences between groups were significantly different, $F(2, 87{,}795) = 4.32$, $p = .01$. A Duncan multiple-range test at the $p < .05$ level indicated that the homosexuals were younger than the bisexuals and heterosexuals, who did not differ from each other.

Educational level was reported by 87,261 of the men. The mean levels for the heterosexual, bisexual, and homosexual groups were 4.28 ($SD = 1.39$), 4.13 ($SD = 1.41$), and 4.40 ($SD = 1.35$), respectively. Thus, the mean reported education of all three groups was "other college," although it is unclear whether this answer had the same meaning for all participants. Americans generally use the phrase "going to college" to mean enrollment in a bachelor's program, whereas British subjects and residents of Commonwealth countries generally use the phrase "going to university" for the same thing. In any event, a one-way ANOVA demonstrated that the between-groups differences in education were significantly different, $F(2, 87{,}258) = 39.88$, $p < .0001$. A Duncan multiple-range test at the $p < .05$ level showed significant differences between all three groups.

Our index of family size was the participant's number of siblings, excluding the participant himself. The mean numbers of siblings for the heterosexual, bisexual, and homosexual men were 1.80 ($SD = 1.38$), 1.84 ($SD = 1.45$), and 1.86 ($SD = 1.42$), respectively. A one-way ANOVA revealed that the mean differences between groups were significantly different, $F(2, 87{,}795) = 4.90$, $p = .007$. A Duncan multiple-range test at the $p < .05$ level showed that the homosexual men had significantly more siblings than the heterosexual men. The bisexual group, which fell in between, did not differ significantly from either.

The female participants consisted of 64,968 heterosexuals, 5,005 bisexuals, and 2,008 homosexuals. Their mean ages were 31.31 ($SD = 10.83$), 28.33 ($SD = 9.39$), and 33.27 ($SD = 10.75$) years, respectively. A one-way ANOVA showed that the mean differences between groups were significantly different, $F(2, 71{,}978) = 219.20$, $p < .0001$. A Duncan multiple-range test at the $p < .05$ level showed that all between-groups differences were significant; that is, the bisexuals were significantly younger than the heterosexuals, who, in turn, were significantly younger than the homosexuals (lesbians).

Educational level was reported by 71,491 of the women. The mean levels for the heterosexual, bisexual, and homosexual females were 4.23 ($SD = 1.39$), 4.08 ($SD = 1.39$), and 4.32 ($SD = 1.37$), respectively. A one-way ANOVA demonstrated that the between-groups differences in education were significantly different, $F(2, 71{,}488) = 30.02$, $p < .0001$. A Duncan multiple-range test at the $p < .05$ level indicated that all three groups were significantly different, with the bisexuals having the least completed education and the homosexuals having the most.

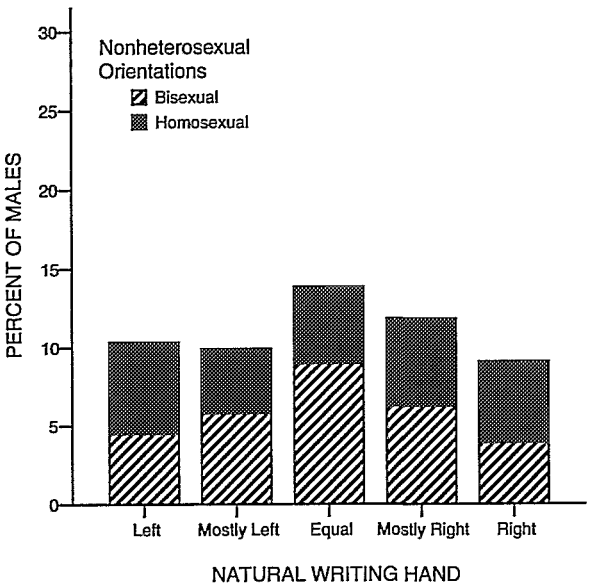

Fig. 1 Sexual orientation in males as a function of writing hand. The figure is read as follows. Of those men who reported that they were (exclusively) left-handed, 10.3% described themselves as nonheterosexual: 4.5% as bisexual and 5.8% as homosexual. The remaining 89.7% of left-handed men (not depicted in the figure) described themselves as heterosexual. The stacked bars for the other hand-preference categories are interpreted similarly.

The mean numbers of siblings for the heterosexual, bisexual, and homosexual women were 1.82 ($SD = 1.40$), 1.57 ($SD = 1.26$), and 1.78 ($SD = 1.40$), respectively. A one-way ANOVA revealed that the mean differences between groups were significantly different, $F(2, 71{,}978) = 70.27$, $p < .0001$. A Duncan multiple-range test at the $p < .05$ level showed that the bisexual women had fewer siblings than the heterosexual or homosexual women, who did not differ from each other.

Handedness

Figure 1 shows the percentages of nonheterosexual (homosexual and bisexual) males as a function of the hand they used for writing. Figure 2 shows the same data for females. Although the response-options between "Left" and "Right" were not labeled on the computer screen, one can infer that the participants who endorsed them were indicating "mostly left," "equally left and right," and "mostly right," and they are so designated in the figures.

To avoid any possible confusion, it is important to note that these figures reverse the traditional presentation of orientation–handedness data. Previous studies have reported the percent of homosexuals who were left-handed (and so on), whereas our figures show the percent of left-handers who were homosexual (and so on). We graphed the

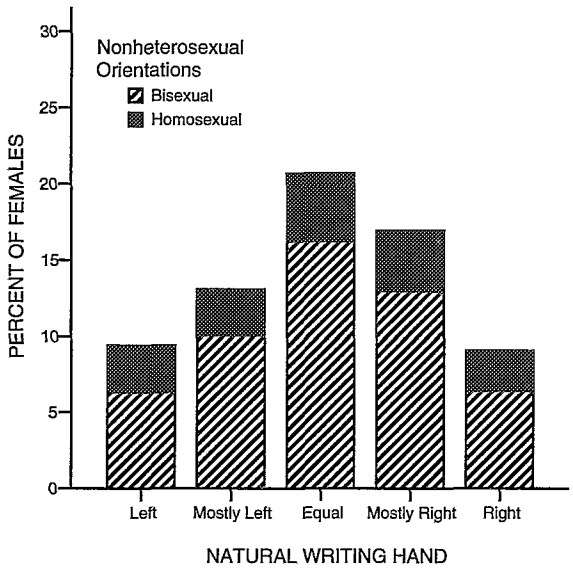

Fig. 2 Sexual orientation in females as a function of writing hand. The figure is read as follows. Of those women who reported that they were (exclusively) left-handed, 9.4% described themselves as nonheterosexual: 6.3% as bisexual and 3.1% as homosexual. The remaining 90.6% of left-handed women (not depicted in the figure) described themselves as heterosexual. The stacked bars for the other hand-preference categories are interpreted similarly.

handedness data in this manner to illustrate the finding, explored below, that the participants who indicated an intermediate degree of writing-hand preference were the ones most likely to describe themselves as nonheterosexual.

For purposes of statistical analysis, the three intermediate degrees of hand-preference were combined into one, so that the participant was categorized as left-handed, mixed-handed, or right-handed. We then cross-tabulated hand-preference with sexual orientation for the male participants and for the female participants. The results are shown in the top and bottom panels of Table 1, respectively. Along with the cell counts, this table displays the traditionally reported handedness percentages (i.e., the percent of heterosexuals who were left-handed, the percent of heterosexuals who were mixed-handed, and so on). Statistical analysis showed that the relation between hand-preference and sexual orientation was significant for both the males, $\chi^2(4, N = 87{,}798) = 108.58$, $p < .0001$, and the females, $\chi^2(4, N = 71{,}981) = 421.31$, $p < .0001$.

Besides the cell counts and row percentages, Table 1 contains the standardized residual for each cell. This is the signed square root of each cell's contribution to the χ^2 value. The standardized residual indicates how much that cell contributed to the effect. A positive value means that the cell collected more cases than expected; a negative value means that it collected fewer cases than expected. Inspection of the standardized residuals in Table 1 showed that the statistical relation between hand-preference and sexual orientation

Table 1 Cross-tabulation of hand-preference with sexual orientation

Sexual orientation	Hand-preference		
	Left	Mixed	Right
Men			
Heterosexual			
Observed	8988	6100	64431
Row%	11.3	7.7	81.0
Standardized residual	−0.95	−2.01	0.99
Bisexual			
Observed	450	441	2772
Row%	12.3	12.0	75.7
Standardized residual	1.55	8.99	−3.39
Homosexual			
Observed	586	370	3660
Row%	12.7	8.0	79.3
Standardized residual	2.57	0.35	−1.08
Women			
Heterosexual			
Observed	6210	4996	53762
Row%	9.6	7.7	82.8
Standardized residual	0.31	−5.89	1.77
Bisexual			
Observed	432	784	3789
Row%	8.6	15.7	75.7
Standardized residual	−2.04	17.88	−5.01
Homosexual			
Observed	211	236	1561
Row%	10.5	11.8	77.7
Standardized residual	1.43	5.26	−2.17

was driven largely by a tendency for people who described themselves as bisexual also to describe themselves as mixed-handed. This was true for the male and for the female participants.

Additional analyses were conducted to determine if the bisexual cases were completely responsible for the significant results of the foregoing χ^2 tests, or if there would still be a relation between sexual orientation and hand-preference when the bisexuals were excluded. The data in Table 1 were re-analyzed using the homosexual and heterosexual participants only. The results showed that the tendency for homosexuals to be non-right-handed was statistically significant for both the males, $\chi^2(2, N = 84{,}135) = 9.73$, $p = .008$, and the females, $\chi^2(2, N = 66{,}976) = 48.92$, $p < .0001$.

Recoding of sexual orientation and handedness variables

In the foregoing analyses, the variables of sexual orientation and hand-preference were coded in a way that helped reveal the correlation between self-reported bisexuality and ambidexterity. For the remainder of this study, these polychotomous variables were coded into dichotomous variables in order to conform to the first author's previous research on hand-preference, older brothers, and sexual orientation.

Table 2 Number and sex ratio of older siblings for all participants

Group	Participants	Older brothers	Older sisters	Sibling sex ratio	two-tailed *p*
Right-handed heterosexual males	69362	31071	30828	101	≪.0001
Non-right-handed heterosexual males	10157	4509	4540	99	.001
Right-handed homo/bisexual males	7093	3734	3577	104	n.s.
Non-right-handed homo/bisexual males	1186	653	658	99	n.s.
Right-handed heterosexual females	57793	27613	24866	111	≪.0001
Non-right-handed heterosexual females	7175	3256	3061	106	n.s.
Right-handed homo/bisexual females	6170	2648	2254	117	.0004
Non-right-handed homo/bisexual females	843	362	307	118	n.s.

This was necessary to make the present findings comparable to earlier ones. Thus, the homosexual and bisexual participants were combined into a single group (hereafter, *homo/bisexual*). Participants who indicated that their writing hand was "left," "mostly left," or "equally left and right" were designated *non-right-handed*, and those who indicated that their writing hand was "mostly right" or "right" were designated *right-handed* (see Blanchard et al., 2006). Because the number of participants designated "right-handed" now includes the "mostly-right-handed," the number of such persons is greater in the following analyses (compare, for example, the numbers of heterosexual right-handers in Tables 1 and 2).

Sex ratio of older siblings

Sex ratio bias and stopping rules. Our exclusion of participants with demonstrably inconsistent sibship data did not guarantee that all the remaining participants would have valid sibship data. We investigated this problem further by utilizing the closest thing to a gold standard in this area of research: the well-established and highly stable human secondary sex ratio (the ratio of male live births to female live births).

Table 2 shows the data of interest: the sibling sex ratio for each group. The sibling sex ratio is usually calculated as the ratio of brothers to sisters collectively reported by a given group of persons. In the present study—as in Williams et al. (2000), Blanchard and Lippa (2007), and Bogaert, Blanchard, and Crosthwait (2006)—it was calculated as the ratio of older brothers to older sisters. In human populations, the ratio of male live births to female live births is close to 106:100 (Chahnazarian, 1988; James, 1987). The ratio of older brothers to older sisters reported by any group of persons drawn at random from the general population should therefore approach 106 (older brothers per 100 older sisters).

The reporting of siblings' sex as the ratio of brothers per 100 sisters is traditional; for the computation of inferential statistics, however, this value is more conveniently expressed as the proportion of brothers rather than the ratio of brothers to sisters, that is, $106 \div 206$ or .515. The sibling sex ratios presented in Table 2 (converted into proportions) were compared with the general population value (.515) using the *z* approximation to the binomial test.

The data show a remarkably consistent pattern of response bias: The male participants reported low sibling sex ratios, and the female participants reported high sibling sex ratios. This can be seen in a variety of ways, starting with an examination of the two largest groups. The sibling sex ratio for the right-handed heterosexual men, 101, was significantly lower than the expected population value of 106. Comparison of the observed and expected values indicated that the probability of this result arising by chance was in the order of 1 in 10 billion. In contrast, the sibling sex ratio for the right-handed heterosexual women, 111, was significantly higher than the expected value of 106. The probability of this result arising by chance was in the order of 1 in one million.

Two of the four male groups (including the heterosexual right-handers) reported sibling sex ratios that differed significantly from the expected value; in both cases, the observed value was lower than 106. Two of the four female groups reported sibling sex ratios that differed significantly from the expected value; in both cases, the observed value was higher than 106. Finally, comparison of the male and female groups shows that every female group had a higher sibling sex ratio than every male group.

Another way of stating these findings is that the male participants had an excess of older sisters, and the female participants had an excess of older brothers. Is there any known phenomenon that might explain these bizarre results? One possible explanation is that the parents of the BBC participants were strongly influenced, in their family planning, by a stopping rule. A *stopping rule* is a rule that parents follow in deciding whether to have another child (e.g., Keyfitz, 1968). One stopping rule, which is common in traditional societies, is "Continue having children until you produce at least one boy" (e.g., Clark, 2000; Wen, 1993). Another stopping rule, which is common in Western, developed societies, is "Continue having children until you have offspring of both sexes" (e.g., Ben-Porath & Welch, 1976; Myers & Roberts, 1968; Sloane & Lee, 1983). The second stopping rule, pursued to its logical extreme, would result in a situation in which the last-born child in any sibship is always opposite in sex to the

Table 3 Percent of participants with older brothers, older sisters, or both, whose parents went on to have more children after the participant

Participants	Had younger siblings	
	No	Yes
Males with older sisters		
Observed	11837	5847
Row%	66.9%	33.1%
Standardized residual	2.1	−2.9
Males with older brothers		
Observed	11304	6914
Row%	62.0%	38.0%
Standardized residual	−6.0	8.3
Males with both		
Observed	7891	3459
Row%	69.5%	30.5%
Standardized residual	5.1	−7.0
Females with older sisters		
Observed	8135	5133
Row%	61.3%	38.7%
Standardized residual	−6.2	8.5
Females with older brothers		
Observed	10474	5121
Row%	67.2%	32.8%
Standardized residual	2.3	−3.2
Females with both		
Observed	6372	2825
Row%	69.3%	30.7%
Standardized residual	4.3	−5.9

older siblings. Thus, the second stopping rule might explain why the BBC sample, which naturally included a substantial proportion of last-born participants, reported an overall excess of opposite-sex older siblings.

The first step in testing this explanation was proving that the participants' parents' decisions to have additional children had, in fact, been influenced by the sexes of the children that they already had. This hypothesis prompted an easily testable prediction: Participants whose older siblings were the same sex as themselves should be more likely to have younger siblings than participants whose older siblings were the opposite sex as themselves. For example, a male participant with two older brothers should be more likely to have a younger sibling than a male participant with two older sisters. The rationale for this prediction is that, in the first case, the parents would be motivated to have another child after the participant in the hope of producing a girl (and thus obtaining children of both sexes); in the second case, the parents already have children of both sexes. A similar prediction and rationale may be found in Ben-Porath and Welch (1976).

The basic data needed to test the prediction are presented in Table 3. The male and female participants were both divided into three groups: those who had older sisters only, those who had older brothers only, and those who had older siblings of both sexes. (First-born participants—participants with no older siblings—were not informative for this analysis and were excluded from it.) The table shows the percentage of subjects in each group who had one or more younger siblings.

The results confirmed the prediction. Male participants with older brothers and female participants with older sisters were more likely to have younger siblings than were male participants with older sisters or female participants with older brothers. The results also showed that the sex of the participants themselves had no observable effect on the operation of the stopping rule. Male and female participants who had older siblings of their own sex included virtually identical percentages with younger siblings (38.0 and 38.7%, respectively). Similarly, male and female participants who had older siblings of the opposite sex included nearly identical percentages with younger siblings (33.1 and 32.8%, respectively). The relation between the sex of the participants' older siblings (represented by the six groups in Table 3) and the presence or absence of younger siblings was highly significant, $\chi^2(5, N=85{,}312)=373.67$, $p \ll .0001$. Inspection of the standardized residuals suggests that the effect was primarily driven by the participants with same-sex older siblings (ultimately, by the parents of those participants).

The participants with older siblings of both sexes were the least likely of all to have any younger siblings (30.5 and 30.7% for the male and female participants, respectively). We felt that this might have to do with the total number of older siblings, a variable that was not controlled in the χ^2 analysis. We therefore ran another version of this analysis on the same participants, using a logistic regression approach. In this analysis, the participant's own sex was ignored, because the cross-tabulation (Table 3) had shown that variable to be unimportant. The criterion variable was whether the participant had any younger siblings (1 = yes, 0 = no). There were two predictor variables. One was the participant's total number of older siblings (regardless of the siblings' sex). The other was the trichotomous variable, *sex-composition of older siblings* (opposite-sex only, same-sex only, and both sexes). This variable was coded using simple contrasts. The participants who had older siblings of both sexes were used as the reference group. Thus, the participants who had older siblings of their own sex were compared with those who had older siblings of both sexes, and the participants who had older siblings of the opposite sex were also compared with those who had older siblings of both sexes. The results of the analysis are presented in Table 4.

In Table 4, each coefficient, B, represents the change in the log odds of younger siblings for a one-unit increase in the corresponding predictor, controlling for all other predictors in the model. The next column presents the standard error (*SE*) for each B. The Wald statistic and its associated degrees of freedom (*df*) were used to determine the

Table 4 Logistic regression—existence of younger siblings (Yes/No) as a function of the sexes and number of older siblings

Predictor	*B*	*S.E.*	Wald	*df*	*p*	e^B
Sex-composition of older siblings			226.03	2	≪.0001	
Opposite-sex only vs. both sexes	0.01	0.02	0.10	1	n.s.	1.01
Same-sex only vs. both sexes	0.24	0.02	96.11	1	≪.0001	1.27
Number of older siblings	−0.06	0.01	45.10	1	≪.0001	0.94

significance level (p) of each predictor variable. The quantity, e^B, is the multiplicative change in the odds of younger siblings for a one–unit increase in the corresponding predictor, and thus $100 \times (e^B - 1)$ represents the percentage change in the odds for a one–unit increase in that predictor.

The results showed that the participants with same-sex older siblings had 27% greater odds of having younger siblings than the reference group ($e^B = 1.27$), whereas the participants with opposite-sex older siblings had the same odds of having younger siblings as the reference group ($e^B = 1.01$). The first result confirms that parents whose children were all of the same sex were more likely to produce additional children than were parents whose children included both sexes. The second result—the parents of participants with opposite-sex older siblings were no more likely to produce additional children than were the parents of those with mixed-sex older siblings—indicates that it did not matter, in terms of the parents' reproductive decision-making, if the participant was the child that added the second sex to the sibship, or if the sibship already included both sexes before the participant's birth.

In summary, the results provided strong evidence that many parents of the BBC participants were following the stopping rule, "Continue having children until you have offspring of both sexes." It is noteworthy that the absolute number of children the parents already possessed also influenced their decision whether to have any more children, over and above the sex composition of the existing children. Each older sibling decreased the odds that a participant would have younger siblings by 6%.

Older-sibling sex ratio, handedness, and sexual orientation. For purposes of the present paper, the relation of sibling sex ratios to sexual orientation is much more important than the relation of sibling sex ratios to parental stopping rules. From the sex research standpoint, the stopping rule phenomenon is merely a nuisance variable. The foregoing analyses, however, showed that we had to take this variable into account before we attempted to investigate the relations among sibling sex ratio, sexual orientation, and hand preference.

Our results up to this point, along with our theoretical interpretation of them, generated two predictions: (1) The prevalent stopping rule should have a much stronger effect on the older-sibling sex ratios of the last-born participants than on those of the middle-born participants, and (2) the sex ratio phenomena observed in previous studies (e.g., high older-sibling sex ratios for homosexual males) should be more apparent in the middle-born participants.

To test these predictions, we reanalyzed the data in Table 2, dividing the participants into those with no younger siblings (Table 5) and those with one or more younger siblings (Table 6). The sibling sex ratios in Tables 5 and 6 are, in effect, data for last-born and middle-born children, respectively; first-born children do not have any older siblings and therefore do not contribute to these numbers.

The results showed that our predictions were correct. Table 5 shows that the biasing of sex ratios apparent for the sample as a whole (Table 2) is extreme in the subsample of last-born participants. A likely interpretation of these data is that the effects of the stopping rule, "Continue having children until you have offspring of both sexes," were so strong that no other effects could be detected. Even the normal variability in sibling sex ratio data appears to have been somehow suppressed: The sibling sex ratios for the male groups ranged only from 96 to 98.

The sibling sex ratios in Table 6 look much more like the values usually encountered in this type of research, suggesting that the removal of the last-born participants successfully corrected for the effects of the stopping rule. This procedure might, in fact, have slightly over-corrected the data in some mysterious way; the older-sibling sex ratios of the right-handed heterosexual males and right-handed heterosexual females now contain an excess of *same-sex* siblings. In the case of the right-handed heterosexual males, the possible biasing does not appear to be very serious. The observed sibling sex ratio is close to the expected value in absolute terms and differs from it statistically only because of the very large sample size. In fact, the ratio for the right-handed heterosexual males would not be statistically significant if we used a test value of .518 rather than .515, as suggested by James (1998) for analyses involving all-male index cases (i.e., participants).

The key findings in Table 6 are the older-sibling sex ratios for the homo/bisexual males. The results for the right-handed homo/bisexual males showed a high ratio of older brothers to older sisters (121), similar to the ratios observed in prior research. In contrast, the ratio for the non-right-handed homo/bisexual males (108) was very close to the expected population value. These results, therefore, lend support to the notion that older brothers increase the odds

Table 5 Number and sex ratio of older siblings for participants with no younger siblings

Group	Participants	Older brothers	Older sisters	Sibling sex ratio	two-tailed p
Right-handed heterosexual males	31088	20293	21015	97	$\ll$.0001
Non-right-handed heterosexual males	4639	2982	3107	96	$<$.0001
Right-handed homo/bisexual males	3473	2470	2530	98	.003
Non-right-handed homo/bisexual males	634	447	468	96	n.s.
Right-handed heterosexual females	26105	18948	16116	118	$\ll$.0001
Non-right-handed heterosexual females	3210	2187	1990	110	n.s.
Right-handed homo/bisexual females	2954	1931	1623	119	.0007
Non-right-handed homo/bisexual females	391	250	200	125	n.s.

of homosexuality in right-handed men but not in non-right-handed men.

The results for the homosexual women did not differ from the expected value. This was true for both the right-handed and the non-right-handed groups.

Interaction of fraternal birth order and handedness

The first study of the interaction of sexual orientation, handedness, and fraternal birth order (Blanchard et al., 2006) used a logistic regression approach to analyzing the data. To make our findings more comparable to those of the previous research, we also performed this type of analysis.

This investigation comprised a set of identically structured regressions, in which sexual orientation (coded as heterosexual = 0 and homo/bisexual = 1) was the criterion variable, and the participant's numbers of older brothers and older sisters were the predictor variables. Separate analyses were conducted for male and female participants, each divided into four groups: (1) right-handed participants who had no younger siblings, (2) non-right-handed participants who had no younger siblings, (3) right-handed participants who had one or more younger siblings, and (4) non-right-handed participants who had one or more younger siblings. The results for the male participants are shown in Table 7.

The results were largely what one would expect, given the findings already reported. The results for the right-handed men with no younger siblings and for the non-right-handed men with no younger siblings indicated that the homo/bisexual participants had more older siblings of both sexes but no specific excess of older brothers. Because these groups had no younger siblings, a finding of more older siblings is tantamount to a finding of larger family sizes; results for the male participants as a whole had already shown that the homo/bisexual males had larger family sizes (see "Sample Demographics"). Similarly, the absence of any specific excess of older brothers is consistent with the older-sibling sex ratios shown in Table 5, which are virtually identical for the heterosexual and homo/bisexual groups.

The results for the right-handed men with younger siblings show the classic fraternal birth order effect, as typically expressed in a logistic regression framework. Each older brother increased the odds of homo/bisexuality by 15%. Older sisters had no statistically significant effect on those odds, despite a sample size of over 40,000 participants. The observed odds ratio, 1.15, was a little lower than usual. This may have more to do with the heterosexual than with the homo/bisexual group. As previously noted, the older-sibling sex ratio for the right-handed heterosexual males, 110, was a little higher than the general population value (see Table 6). In contrast, the ratio for the right-handed homo/bisexual males, 121, was quite similar to previous results for such males (see Blanchard, 2004).

The results of greatest interest are those for the non-right-handed men with younger siblings. They seem to show a family size effect rather than a fraternal birth order effect; the odds ratios for older brothers and older sisters were relatively similar, and both were statistically significant. The

Table 6 Number and sex ratio of older siblings for participants with younger siblings

Group	Participants	Older brothers	Older sisters	Sibling sex ratio	two-tailed p
Right-handed heterosexual males	38274	10778	9813	110	.02
Non-right-handed heterosexual males	5518	1527	1433	107	n.s.
Right-handed homo/bisexual males	3620	1264	1047	121	.002
Non-right-handed homo/bisexual males	552	206	190	108	n.s.
Right-handed heterosexual females	31688	8665	8750	99	$<$.0001
Non-right-handed heterosexual females	3965	1069	1071	100	n.s.
Right-handed homo/bisexual females	3216	717	631	114	n.s.
Non-right-handed homo/bisexual females	452	112	107	105	n.s.

Table 7 Logistic regressions of sexual orientation onto numbers of older siblings, for separate groups of male participants

Predictor	*B*	*S.E.*	Wald	*df*	*p*	e^B
Right-handers, no younger sibs ($n = 34561$)						
Number of older brothers	0.08	0.02	14.77	1	.0001	1.08
Number of older sisters	0.07	0.02	11.42	1	.0007	1.07
Non-right-handers, no younger sibs ($n = 5273$)						
Number of older brothers	0.09	0.05	3.21	1	.07	1.09
Number of older sisters	0.09	0.05	3.54	1	.06	1.09
Right-handers with younger sibs ($n = 41894$)						
Number of older brothers	0.14	0.03	29.93	1	$\ll$.0001	1.15
Number of older sisters	0.04	0.03	2.54	1	n.s.	1.05
Non-right-handers with younger sibs ($n = 6070$)						
Number of older brothers	0.17	0.07	6.85	1	.009	1.19
Number of older sisters	0.14	0.07	4.43	1	.04	1.15

conclusion that the fraternal birth order effect is not discernable in these men is consistent with their very similar older-sibling sex ratios: 107 for the non-right-handed heterosexual men and 108 for the non-right-handed homo/bisexual men (Table 6).

Blanchard et al. (2006) and Bogaert et al. (2006) based their conclusion that older brothers increase the odds of homosexuality in right-handed men but not in non-right-handed men on their findings that the slope of the line relating the likelihood of homosexuality to older brothers was significantly more positive for right-handed than for non-right-handed men, and that the slope did not differ from zero for non-right-handed men. Casual inspection of the findings for our men with younger siblings (lower half of Table 7) clearly shows that the present data would fail that test. The observed slope for the right-handed men (represented by the *B* coefficient of 0.14) was actually *less* positive than the slope for the non-right-handed men (0.17), and the slope for the non-right-handed men was significantly greater than zero, $p = .009$. What is unclear is whether the test fails because the older brother × handedness interaction is weak or absent in the present data, or because this test is untrustworthy when the examined groups differ too much in mean family size.

The results of parallel analyses conducted on the female participants are shown in Table 8. There was only one discernable effect, which appears unrelated to hand-preference or last-born status: The homo/bisexual women had fewer older siblings than their heterosexual counterparts. This can be seen at a glance by examining the odds ratios (i.e., the column of numbers headed e^B), which show that older brothers and older sisters lowered the odds of homo/bisexuality about equally. This outcome possibly resulted from combining the bisexual women, who had the smallest family sizes (see "Sample Demographics" above) with the homosexual women.

Discussion

The present study yielded some evidence that non-right-handedness is associated with homosexuality in men and women, that older brothers increase the odds of homosexuality in men, and that the effect of older brothers on sexual

Table 8 Logistic regressions of sexual orientation onto numbers of older siblings, for separate groups of female participants

Predictor	*B*	*S.E.*	Wald	*df*	*p*	e^B
Right-handers, no younger sibs ($n = 29059$)						
Number of older brothers	−0.10	0.02	17.84	1	<.0001	0.90
Number of older sisters	−0.10	0.02	17.22	1	<.0001	0.90
Non-right-handers, no younger sibs ($n = 3601$)						
Number of older brothers	−0.06	0.07	0.79	1	n.s.	0.94
Number of older sisters	−0.17	0.07	5.82	1	.02	0.84
Right-handers with younger sibs ($n = 34904$)						
Number of older brothers	−0.10	0.03	7.98	1	.005	0.91
Number of older sisters	−0.23	0.04	38.30	1	$\ll$.0001	0.79
Non-right-handers with younger sibs ($n = 4417$)						
Number of older brothers	−0.04	0.09	0.22	1	n.s.	0.96
Number of older sisters	−0.09	0.09	0.98	1	n.s.	0.91

orientation is limited to right-handed men. This evidence, however, was weaker and more inconsistent than it has been in several previous studies, and it required special procedures for its observation. There are many possible reasons for this. One possibility is simply that Internet research participants respond less conscientiously than do conventionally examined participants. Another possibility—almost a certainty—is that the usual relations among hand preference, sibship sex composition, and sexual orientation were partially obscured by the powerful effects of other variables. The nature of these other variables will be discussed in the paragraphs to follow.

Handedness and sexual orientation in males and females

Insofar as we found a significant correlation between non-heterosexuality and non-right-handedness, our results appear to confirm those of previous studies (see Lalumière et al., 2000). More detailed analyses suggested caution, however, in interpreting our findings as simply one more replication. Our results were driven, to a large extent, by a tendency for people who described themselves as ambidextrous also to describe themselves as bisexual. It is possible that this finding reflects some sort of response bias, rather than a genuine natural phenomenon. We can only speculate on the nature of such a response bias. It might reflect a desire to present oneself as exotic and unusual, unfettered by convention and fixed categories, or fluid in behavioral potential; it might reflect a generalized tendency to endorse the intermediate rather than the extreme response-options of any questionnaire item; or it might reflect a stronger than average drive for precision ("I have *sometimes* tried to write with my other hand," "I have *sometimes* imagined sex with a man/woman").

When we excluded the bisexual participants and investigated handedness in homosexuals and heterosexuals only, we did confirm the meta-analytic finding that homosexual men and women have higher rates of non-right-handedness than their heterosexual counterparts (Lalumière et al., 2000). Non-right-handedness therefore appears to be one of the two traits that correlate reliably with homosexuality in both men and women (the other trait being gender-atypical behavior and interests; Bailey & Zucker, 1995; Lippa, 2005).

Older brothers and sexual orientation in males

The relation between a male participant's sexual orientation and his number of older brothers was examined in two different ways. The first approach was comparing the ratio of older brothers to older sisters in the homo/bisexual and heterosexual groups. This approach immediately led to a powerful and unexpected finding: The male participants in the BBC sample reported an excess of older sisters, and the female participants reported an excess of older brothers. This phenomenon was so strong that it seemed to obscure all other sex ratio effects of potential interest, and it therefore presented a problem that had to be solved before any other analysis of sibling sex ratios could proceed.

Subsequent analyses supported the hypothesis that the biased older-sibling sex ratios were an artifact of a parental stopping rule. A *stopping rule* is a rule that parents follow in deciding whether to have another child (e.g., Keyfitz, 1968). It appears that the parents of the BBC participants were following the stopping rule, common in Western, industrialized societies, "Continue having children until you have offspring of both sexes" (e.g., Ben-Porath & Welch, 1976; Myers & Roberts, 1968; Sloane & Lee, 1983). This stopping rule, followed with complete consistency, results in a situation in which the last-born child in any sibship is always opposite in sex to the older siblings. Thus, it can explain why the BBC sample, which naturally included a substantial proportion of last-born participants, reported an overall excess of opposite-sex older siblings.

Our solution to the problem of stopping rule contamination was to divide the sample into participants who had no younger siblings (last-born individuals) and participants who had one or more younger siblings. As we expected, the participants with no younger siblings manifested even more strongly biased older-sibling sex ratios, whereas the participants with younger siblings yielded data generally similar to those observed in previous research.

The ratio of older brothers to older sisters for the right-handed homo/bisexual men with younger siblings was 121 (older brothers per 100 older sisters). This was significantly higher than the test value of 106 (the human sex ratio at birth). It was, furthermore, identical to the value previously obtained by Blanchard (2004, Figure 2) using aggregate data from 14 homosexual groups comprising 3,181 individual men (who were not classified by hand-preference and thus were presumably overwhelmingly right-handed).

A remaining mystery is why the parental stopping rule exerted such strong effects on the BBC data that it necessitated a special work-around—a situation never previously encountered by the first author in other data sets. This may relate to self-selection biases in volunteers for Internet studies or to sampling biases arising from the advertisement and promotion of the study by the BBC. It is possible that the parents of the BBC participants were particularly middle-class and Western (or Westernized) in their attitudes, and that they were motivated both to have children of both sexes and to minimize their total family size. That could mean that they not only continued procreating until they had children of both sexes but also that they stopped procreating immediately thereafter. Such a situation would maximize the tendency for last-born participants to have opposite-sex older siblings. If this analysis is correct, then one may expect that future studies of fraternal birth order and homosexuality will have to deal with similar phenomena. It has been asserted that the

influence of the sex composition of existing children on parents' subsequent procreation may increase as family sizes decrease in industrialized countries, because the factors that affect parents' decision to have another child (e.g., stopping rules) become more important (Sloane & Lee, 1983; Wood & Bean, 1977).

The second approach to examining the relation between older brothers and sexual orientation in men involved the use of logistic regression. Capitalizing on our experience with the sibling sex ratio data, we conducted separate logistic regression analyses for men with and without younger siblings. The results for the right-handed men with younger siblings showed the classic fraternal birth order effect. Each older brother increased the odds of homo/bisexuality by 15%. In contrast, older sisters had no statistically significant effect on those odds, despite a sample size of over 40,000 participants.

Interaction of older brothers and handedness

The main goal of the present research was to test the hypothesis that the effect of older brothers on sexual orientation is limited to right-handed men. The results from the sibling sex ratio analyses of the men with younger siblings tended to support the hypothesis. The older-sibling sex ratio of the right-handed homo/bisexual men, as previously noted, was 121. In contrast, the older-sibling sex ratio of the non-right-handed homo/bisexual men was 108, which is very close to the expected value of 106 in absolute terms, and did not differ statistically from it. The conclusion that non-right-handed homosexual men do not have a higher than expected ratio of older brothers to older sisters was also recently reached by Blanchard (2007), based on an analysis of 341 participants.

The results of the logistic regression analyses, on the other hand, did not help much to clarify whether older brothers have differential effects on right-handed and non-right-handed males. (The following discussion pertains to men with younger siblings, the participants for which the data were potentially informative. See lower half of Table 7.) If one compares the older-brothers odds ratio for non-right-handers (1.19) with the older-brothers odds ratio for right-handers (1.15), then one might conclude that older brothers predict homosexuality in non-right-handed men as well as they do in right-handed men. If, however, one compares the older-brothers odds ratio for non-right-handers (1.19) with the older-*sisters* odds ratio for the non-right-handers (also 1.15), then one might conclude that number of older siblings, and not number of older brothers, predicts homosexuality in non-right-handed men. In other words, the first comparison leads to the conclusion that right-handed and non-right-handed homo/bisexual men both have a high fraternal birth order; the second comparison leads to the conclusion that non-right-handed homo/bisexual men do not have a high fraternal birth order but rather a large family size. Thus, the implications of the logistic regression analyses were ambiguous.

Miscellany

Blanchard (2007) found a high older-sibling sex ratio (127) in non-right-handed heterosexual men. This was not confirmed in the present study, in which the ratio for non-right-handed heterosexual men with younger siblings was 107—nearly identical to the expected population value. Blanchard and Lippa (2007) found an extremely high older-sibling sex ratio (186) in non-right-handed homosexual females. This was also not confirmed in the present study, in which the ratio for non-right-handed homo/bisexual females with younger siblings was 105. Direct comparison of these earlier results with the present ones may be problematic, however, because the present estimates were calculated on a subsample that excluded last-born children.

Camperio-Ciani et al. (2004) and King et al. (2005) found evidence that the relatives of homosexual men are more fertile than the relatives of heterosexual men. This may be related to the present finding that the homosexual men had significantly more siblings than the heterosexual men, with the bisexual group falling in between. We did not explore the differences in sibship size in more detail, because that would have required extensive analysis of potentially confounded demographic and ethnic variables, and because sibship size was not a focus of our study.

Methodology in future research

There are various things that future research on this topic might do, besides gathering more evidence on whether older brothers have differential effects on sexual orientation in right-handed and non-right-handed men. Investigators could, for example, try to distinguish "genetic" non-right-handedness in their participants from "pathological" non-right-handedness (see Blanchard & Lippa, 2007).

Whatever its specific focus or innovation, research designed in advance to investigate the handedness × birth order interaction should employ quality control measures to ensure the accuracy of the participants' sibship data. In the paper questionnaire used in the first author's laboratory, this is done by soliciting sibship data in multiply redundant ways. On one page, examinees are asked how many boys the examinee's mother delivered before she delivered the examinee, how many girls before the examinee, how many boys after the examinee, and how many girls after the examinee. Other items on that page ask the sex of the child (if any) born immediately before the examinee, whether the examinee is a twin, and how many sets of twins the mother delivered. On a different page, examinees are asked to list all children born

to their mother (including themselves), in the order of their birth. They are also asked to give the age of each sibling (or if they are dead, the age they would have been today), whether that sibling is dead or alive, whether that sibling had the same biological father as the examinee, and whether that sibling was a twin. Various other related items are scattered throughout the questionnaire, for example, one asking examinees whether they know enough about their mother to list all her live births with confidence. This system of multiple redundancies was designed with the express purpose of revealing inconsistent responses, and in practice, it reveals a great many. This amount of cross-checkable information is rarely encountered in archival data sets, but there is no reason it should not be the standard in research designed in advance to study the effects of birth order on sexual orientation or other behavioral variables.

Summary

The survey responses of the BBC participants posed unusual challenges to data analysis. About 20% of the participants apparently misunderstood or ignored the instructions for providing sibship information. Furthermore, the sibship data and the handedness data of the remaining participants were strongly affected by factors that have not previously been observed in this line of research. Despite these circumstances, the present study, like earlier studies on this topic (Blanchard, 2007; Blanchard & Lippa, 2007; Blanchard et al., 2006; Bogaert et al., 2006), pointed to the conclusion that older brothers increase the odds of homosexuality in right-handed males but not in non-right-handed males.

Possible proximate mechanisms for the older brothers × handedness × sexual orientation interaction have been suggested by Blanchard et al. (2006). An adaptationist explanation was attempted by Blanchard (2007), who suggested that non-right-handedness may have evolved or persisted as a fetal defense against the effect of older brothers on sexual orientation. One of the many tasks for future research on sexual orientation will be designing studies that can help decide among these possibilities.

References

Bailey, J. M., & Zucker, K. J. (1995). Childhood sex-typed behavior and sexual orientation: A conceptual analysis and quantitative review. *Developmental Psychology, 31,* 43–55.

Ben-Porath, Y., & Welch, F. (1976). Do sex preferences really matter? *Quarterly Journal of Economics, 90,* 285–307.

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. (2007). Sex ratio of older siblings in heterosexual and homosexual, right-handed and non-right-handed men. *Archives of Sexual Behavior.* DOI: 10.1007/s10508-006-9119-2.

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

Blanchard, R., & Bogaert, A. F. (1998). Birth order in homosexual versus heterosexual sex offenders against children, pubescents, and adults. *Archives of Sexual Behavior, 27,* 595–603.

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., & Klassen, P. (1997). H-Y antigen and homosexuality in men. *Journal of Theoretical Biology, 185,* 373–378.

Blanchard, R., & Lippa, R. A. (2007). The sex ratio of older siblings in non-right-handed homosexual men. *Archives of Sexual Behavior.* DOI: 10.1007/s10508-006-9107-6.

Bogaert, A. F. (2006). Biological versus nonbiological older brothers and men's sexual orientation. *Proceedings of the National Academy of Sciences of the United States of America, 103,* 10771–10774.

Bogaert, A. F., Blanchard, R., & Crosthwait, L. E. (2006). *Interaction of birth order, handedness, and sexual orientation in the Kinsey interview data.* Manuscript in preparation.

Camperio-Ciani, A., Corna, F., & Capiluppi, C. (2004). Evidence for maternally inherited factors favouring male homosexuality and promoting female fecundity. *Proceedings of the Royal Society of London B, 271,* 2217–2221.

Chahnazarian, A. (1988). Determinants of the sex ratio at birth: Review of recent literature. *Social Biology, 35,* 214–235.

Clark, S. (2000). Son preference and sex composition of children: Evidence from India. *Demography, 37,* 95–108.

Green, R. (2000). Birth order and ratio of brothers to sisters in transsexuals. *Psychological Medicine, 30,* 789–795.

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

James, W. H. (1998). The sex ratios of the sibs of children with psychiatric diagnoses. *Journal of Child Psychology and Psychiatry, 39,* 595.

Keyfitz, N. (1968). *Introduction to the mathematics of population.* Reading, MA: Addison-Wesley Publishing.

King, M., Green, J., Osborn, D. P. J., Arkell, J., Hetherton, J., & Pereira, E. (2005). Family size in white gay and heterosexual men. *Archives of Sexual Behavior, 34,* 117–122.

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

Lippa, R. A. (2003). Handedness, sexual orientation, and gender-related personality traits in men and women. *Archives of Sexual Behavior, 32,* 103–114.

Lippa, R. A. (2005). Sexual orientation and personality. *Annual Review of Sex Research, 16,* 119–153.

Mustanski, B. S., Bailey, J. M., & Kaspar, S. (2002). Dermatoglyphics, handedness, sex, and sexual orientation. *Archives of Sexual Behavior, 31,* 113–122.

Myers, G. C., & Roberts, J. M. (1968). A technique for measuring preferential family size and composition. *Eugenics Quarterly, 15,* 164–172.

Rahman, Q. (2005). Fluctuating asymmetry, second to fourth finger length ratios and human sexual orientation. *Psychoneuroendocrinology, 30,* 382–391.

Reimers, S. (2007). The BBC internet study: General methodology. *Archives of Sexual Behavior, 36,* DOI: 10.1007/s10508-006-9143-2

Robinson, S. J., & Manning, J. T. (2000). The ratio of 2nd to 4th digit length and male homosexuality. *Evolution and Human Behavior, 21,* 333–345.

Sloane, D. M., & Lee, C.-F. (1983). Sex of previous children and intentions for further births in the United States, 1965–1976. *Demography, 20,* 353–367.

Wen, X. (1993). Effect of son preference and population policy on sex ratios at birth in two provinces of China. *Journal of Biosocial Science, 25,* 509–521.

Williams, T. J., Pepitone, M. E., Christensen, S. E., Cooke, B. M., Huberman, A. D., Breedlove, N. J., et al. (2000). Finger-length ratios and sexual orientation. *Nature, 404,* 455–456.

Wood, C. H., & Bean, F. D. (1977). Offspring gender and family size: Implications from a comparison of Mexican Americans and Anglo Americans. *Journal of Marriage and the Family, 39,* 129–139.