From the Cover: Biological versus nonbiological older brothers and men's sexual orientation

Anthony F. Bogaert

PNAS 2006;103;10771-10774; originally published online Jun 28, 2006;
doi:10.1073/pnas.0511152103

Biological versus nonbiological older brothers and men's sexual orientation

Anthony F. Bogaert*

Departments of Community Health Sciences and Psychology, Brock University, St. Catharines, ON, Canada L2S 3A1

Edited by Dale Purves, Duke University Medical Center, Durham, NC, and approved May 17, 2006 (received for review December 29, 2005)

The most consistent biodemographic correlate of sexual orientation in men is the number of older brothers (fraternal birth order). The mechanism underlying this effect remains unknown. In this article, I provide a direct test pitting prenatal against postnatal (e.g., social/rearing) mechanisms. Four samples of homosexual and heterosexual men (total $n = 944$), including one sample of men raised in nonbiological and blended families (e.g., raised with half- or step-siblings or as adoptees) were studied. Only biological older brothers, and not any other sibling characteristic, including nonbiological older brothers, predicted men's sexual orientation, regardless of the amount of time reared with these siblings. These results strongly suggest a prenatal origin to the fraternal birth-order effect.

immune | sexuality

Recent research has provided evidence that genetic and prenatal factors may influence sexual orientation development (1–7). In this article, I demonstrate that the number of biological older brothers, including those not reared with the participant (but not the number of nonbiological older brothers), increases the probability of homosexuality in men. These results provide evidence that a prenatal mechanism(s), and not social and/or rearing factors, affects men's sexual orientation development.

The most consistent biodemographic correlate of sexual orientation in men is the number of older brothers, originally observed by Blanchard and Bogaert (8) in a Canadian sample in the 1990s but since then found in samples from different eras and from different countries, both by us and independent investigators (2, 7, 9–12). Evidence does not exist that sibling characteristics reliably correlate with women's sexual orientation (13, 14). Both childhood social/rearing (13, 15, 16) and prenatal (8, 13) mechanisms have been advanced to account for the older brother ("fraternal birth-order") effect in men, but a direct test pitting prenatal versus postnatal (e.g., social/rearing) mechanisms is lacking. Such a test is possible when information on both biological and nonbiological siblings, along with sexual orientation, is included in the research design.

Four samples of homosexual and heterosexual men (total $n = 944$) reporting on their parental and sibling characteristics (i.e., biological and nonbiological siblings) were examined to test this issue. Three samples were archival and contained men with (largely) biologically intact families. These samples contained information on all siblings (both biological and nonbiological) with whom the participant was reared. The fourth sample was recruited specifically to test the research issue investigated in this article and contained men with nonbiological or blended families (e.g., raised with half- or step-siblings or as adoptees). This final sample also contained information on the amount of time the participants were reared with each sibling, along with information on any biological siblings with whom they were never reared.

If rearing or social factors associated with older male siblings underlies the fraternal birth-order effect, then all older brothers reared with the participant should predict sexual orientation because all of these older male siblings (both biological and nonbiological) share the social/rearing environment with their younger male siblings. If a prenatal factor underlies the fraternal birth-order effect, however, then only biological older brothers should predict sexual orientation because only biological older brothers (and not nonbiological older brothers) share prenatal characteristics (e.g., gestated by the same biological mother) with their younger male siblings. Second, if rearing or social factors underlie the fraternal birth-order effect, then the amount of time reared with older brothers, either biological or nonbiological, should predict sexual orientation because rearing time indexes the relative opportunity that older brothers have to affect their younger sibling's (postnatal) sociosexual development. If a prenatal factor underlies the fraternal birth-order effect, however, then a postnatal factor such as rearing time with older siblings (be they biological or nonbiological) should have no impact on the sexual orientation of younger male siblings. Finally, if rearing or social factors underlie the fraternal birth-order effect, then the number of biological older brothers with whom the participants were not reared should not predict sexual orientation because they should have no impact on the (postnatal) sociosexual environment of their younger brothers. If a prenatal factor underlies the fraternal birth-order effect, however, then biological older brothers with whom the participants were not reared should predict sexual orientation because all biological older brothers, even those not reared with the participants, share prenatal characteristics (e.g., gestated by the same mother) with their young male siblings.

Results and Discussion

In the first analysis, I used all four samples and entered age (which related to sexual orientation, with homosexual participants being older) and eight sibling variables (the number of biological older brothers reared with, the number of nonbiological older brothers reared with, the number of biological older sisters reared with, etc.) into a linear regression analysis predicting sexual orientation. Fig. 1 presents the standardized regression weights (βs) for all eight sibling characteristics, along with 95% confidence intervals. Significant β coefficients differ statistically from zero and, when positive, indicate a greater probability of homosexuality. Only the number of biological older brothers reared with the participant, and not any other sibling characteristic including the number of nonbiological brothers reared with the participant, was significantly related to sexual orientation.

In the second analysis, I examined whether the time reared with each sibling, along with all biological siblings (reared with or not), predicted sexual orientation. I selected the fourth sample (nonbiological and blended families) and only those from the 521 men in this sample with valid information on age, biological siblings (reared with or not), nonbiological siblings, and maternal age (i.e., the biological mother's age at the participant's birth). Maternal age was included in this analysis for

Conflict of interest statement: No conflicts declared.

This paper was submitted directly (Track II) to the PNAS office.

See Commentary on page 10531.

*E-mail: tbogaert@brocku.ca.

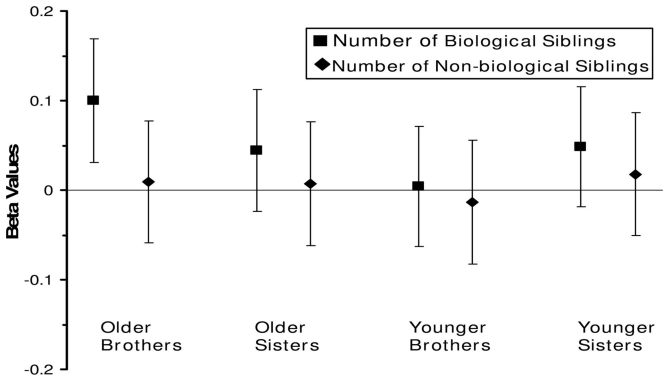

Fig. 1. In the full sample, β coefficients and 95% confidence intervals for biological and nonbiological siblings reared with the participant predicting homosexual sexual orientation. β values are standardized regression weights. They are statistically significant when zero is not included within the 95% confidence interval. A β value of 0.10 for the number of older brothers indicates a 0.10 SD difference in sexual orientation, holding constant the other predictors in the model.

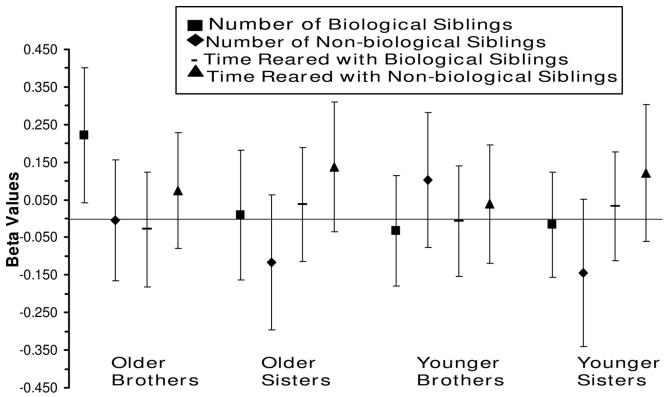

Fig. 2. In sample 4, β coefficients and 95% confidence intervals for sibling characteristics predicting homosexual sexual orientation.

two reasons. First, parental age may be a confounding factor in birth-order research, thus demonstrating that an older brother effect independent of parental (e.g., maternal) age is important. Indeed, maternal age was related to sexual orientation in the present sample, with homosexual men's mothers being significantly younger than the mothers of heterosexual men. Second, maternal age was included in this analysis because individuals knowing their mother's age were likely to give reliable information on all biological siblings, including those biological siblings with whom they were not reared. Many of the participants in this fourth sample had, as mentioned, biological siblings with whom they were not reared.

Along with age and maternal age, eight sibling variables [e.g., the number of biological older brothers (reared with or not), the number of nonbiological older brothers, the number of biological older sisters (reared with or not), etc.] were included in this analysis. Eight variables representing the number of years reared with each sibling type (e.g., the number of years reared with biological older brothers, the number of years reared with nonbiological older brothers, the number of years reared with biological older sisters, etc.) were also included in this second regression analysis. Thus, 18 predictors were entered simultaneously into the linear regression analysis predicting sexual orientation.

Despite weaker power than the previous analysis (valid $n = 378$), very similar results occurred: Only biological older brothers (reared with or not) and no other sibling characteristic, including nonbiological older brothers and the time reared with older biological or older nonbiological brothers, predicted men's sexual orientation. Fig. 2 presents the standardized regression weights (βs), along with the 95% confidence intervals, for the 16 sibling characteristics.

In the third and similar analysis, I restricted the sample further, using only participants with at least one nonbiological sibling. Such restriction ensured that a high proportion of nonbiological siblings relative to biological siblings (e.g., 144 nonbiological older brothers versus 118 biological older brothers) were available for analysis. Hence, the opportunity for a social/environmental effect via being reared with (nonbiological) older male siblings should be relatively high. Despite even weaker power (valid $n = 260$), very similar results occurred: Again, only biological older brothers (reared with or not) and no other sibling characteristic, including nonbiological older brothers and the time reared with older biological or nonbiological brothers, predicted men's sexual orientation.

In the final analysis, I examined whether the effect of biological older brothers is partially accounted for by biological older brothers with whom the participants were not reared. In other words, can biological older brothers not reared with, independent of (or over and above) biological older brothers reared with, predict men's sexual orientation? To examine this issue, I again used sample 4 and entered as predictors both biological older brothers reared with participants and biological older brothers not reared with participants, along with age and maternal age, into a fourth regression analysis predicting sexual orientation. Both biological older brother variables independently predicted sexual orientation, and these effects occurred despite a lower number of biological older brothers not reared with participants (75) relative to biological older brothers reared with participants (117).

If rearing or social factors associated with older male siblings underlies the fraternal birth-order effect, then the number of nonbiological older brothers should predict men's sexual orientation, but they do not. These results occurred in both the combined samples and the sample (4) recruited specifically to test this issue. Even when the number of nonbiological older brothers significantly exceeded the number of biological older brothers, and hence the opportunity for an effect via being reared with (nonbiological) older male siblings was high, only the number of biological older brothers and not nonbiological older brothers predicted sexual orientation in men. Moreover, the amount of time reared with older brothers, either biological or nonbiological, neither predicted sexual orientation nor affected the (biological) older brother relation to sexual orientation. Finally, if rearing or social factors underlie the fraternal birth-order effect, the number of biological older brothers with whom they were not reared should not predict men's sexual orientation because they should have no impact on the sociosexual environment of their younger brothers. Yet, these brothers do predict men's sexual orientation just as the number of biological older brothers with whom they were reared.

These results support a prenatal origin to sexual orientation development in men and indicate that the fraternal birth-order effect is probably the result of a maternal "memory" for male gestations or births. Note that if it is a memory for male gestations (and not merely male births), then miscarriages and/or abortions of male fetuses may be relevant, and the mechanism underlying the fraternal birth effect may be stronger than previously demonstrated. This potentially weaker effect is because miscarriage/abortion information is usually lacking in sexual orientation studies and thus has not been included in estimates of the size of the effect (17).

A theory of male homosexuality consistent with the present findings is a maternal immune response to succeeding male pregnancies (8, 18–20). This explanation is partly based on the idea that a woman's immune system would appear to be capable of remembering the number of male fetuses she has previously carried and of progressively altering its response to the next fetus

according to the current tally of preceding males. A mother's body may have a memory for male (but not female) fetuses because she herself is female, and thus, her immune system may interpret and remember male (but not female) fetuses as foreign (21). If this immune theory were correct, then the link between the mother's immune reaction and the child's future sexual orientation would probably be some effect of maternal anti-male antibodies on the sexual differentiation of the brain. Recent formulations of this theory focus on male-specific, Y-linked H–Y antigen or male-specific cell-surface proteins (e.g., protocadherins) as the relevant fetal antigen (8, 18, 22). No direct support exists for a maternal immune response that underlies the fraternal birth-order effect, but various lines of evidence exist in this theory's favor and have been reviewed elsewhere (18, 22).

Finally, note that most of our prior studies found no difference between heterosexual and homosexual men in parental (e.g., maternal) age or found that an older parental age in homosexual samples was probably a consequence of a late (fraternal) birth order (8, 9, 23). That homosexual men in the present study had younger (and not older) mothers relative to the heterosexual men provides additional support that the fraternal birth-order effect does not occur because of a potential confounding influence of an elevated parental age in the mothers of homosexual men. A relatively young maternal age in homosexual men may be unique to the present study, which contains a high number of men from adopted and blended families (e.g., sample 4). Stressors associated with a young first pregnancy in the mothers of adopted sons may alter the fetal environment (e.g., lower prenatal testosterone), and this finding may represent a separate pathway to the development of homosexuality in these men. Research using animal models (24, 25), along with some human studies (26), indicates that maternal stress may be a significant factor in the alteration of sexual orientation development.

Materials and Methods

As indicated, data comprised information from four samples of homosexual and heterosexual men (total $n = 944$), three of which were archival in nature, whereas the fourth was a new sample recruited specifically to test the research issue investigated here. Two of the archival samples were of heterosexual undergraduate men at Brock University in the Niagara region of Canada, recruited for studies on sexual attitudes ($n = 141$). The other archival sample was a community-oriented sample of gay/bisexual men from Toronto and the Niagara region of Canada, recruited primarily to explore sexual health issues ($n = 282$). The fourth (nonarchival) sample was a community sample of gay/bisexual and heterosexual men ($n = 521$) raised in nonbiological or blended families (e.g., raised with half- or step-siblings or as adoptees), recruited from various regions of Canada (Toronto and the surrounding regions, Montreal, and Vancouver). For the latter two samples, to recruit a sufficiently large number of homosexual men who represent a smaller percentage of the population than heterosexual men, advertisements were placed in a number of gay-oriented publications. Similar advertisements were then placed in general publications to recruit heterosexual participants in sample 4. To ensure a high number of participants from nonbiological families for this fourth sample, the advertisements requested individuals reared in nonbiological families (e.g., with adopted or step-siblings or as adoptees). Approximately 45% of this sample was adopted, whereas the remainder was raised in other situations that entailed some form of nonbiological or blended family (e.g., parents divorced, child sent away, reared with adopted siblings, etc.).

All of the men were asked for their year of birth/age, educational level, and ages of parents (e.g., biological mother). Maternal age at the participant's birth was calculated by subtracting the participant's age from his mother's current age or the age that a (deceased) mother would be if she were alive. Two questions on sexual orientation were posed: (*i*) sexual attraction toward men and women (i.e., sexual thoughts and feelings), ranging from 1, "exclusively homosexual/gay," to 7, "exclusively heterosexual/straight"; and (*ii*) sexual behaviors (i.e., actual experiences) engaged in with men and women, ranging from 1, "exclusively homosexual/gay," to 7, "exclusively heterosexual/straight." These two measures of sexual orientation were reverse-coded (so that high scores indicated homosexuality) and then averaged.

The men in all four samples were also asked to indicate their number of siblings (i.e., number of older brothers, number of older sisters, etc.) with whom they were raised and to indicate whether they were "biological" (i.e., born from same mother as the participant) or not. Hence, siblings born from the same biological mother as the participants were labeled in the present study as "biological"; all other siblings were referred to "nonbiological." Most biological theories describe maternal mechanisms (e.g., maternal immune response) as most relevant to the fraternal birth-order effect. Thus, all four samples had information on all siblings (both biological and nonbiological) raised with the participants. In addition, the participants in samples 1 and 2 (Brock University undergraduates) and 4 (nonbiological and blended families) were asked to indicate the number of years lived with each sibling while growing up (rearing time), along with any (known) biological siblings with whom they were not raised. Thus, in addition to the information on biological and nonbiological siblings with whom the participants were reared, these samples had information on the amount of time reared with each sibling, along with information on biological siblings with whom they were not reared (e.g., the number of biological older brothers never reared with). Information on the number of biological siblings with whom the participant was not reared is particularly relevant for sample 4 because a high percentage of participants in this sample had such siblings (e.g., adopted participants). Rearing time was calculated by summing the number of years lived with all siblings within each sibling type (i.e., biological older brothers, biological older sisters, etc.), so that, for example, a man who lived 2 years with one older biological brother while growing up (until 18) and 13 years with another would have a score of 15.

Of the 944 men in the combined sample, 905 were not twins themselves and had complete data on the relevant sibling variables, along with age and sexual orientation. Education was unrelated to sexual orientation and thus not included in the analysis. The distribution of these 905 men on the sexual orientation variable was as follows: 329 scored ≤ 2 (exclusive or near exclusive heterosexuality), 151 scored between 2 and 6 (bisexuality), and 425 scored ≥ 6 (exclusive or near exclusive homosexuality).

I thank R. Blanchard, A. Bradley, J. Cantor, N. Culp, C. Hafer, C. Hopkins, C. Irwin, L. K. Jamieson, and J. Zavitz for their help at various stages of this research. This research was supported by Social Sciences and Humanities Research Council of Canada Grant 410-99-0521 (to A.F.B.).

1. Bailey, J. M., Dunne, M. P. & Martin, N. G. (2000) *J. Pers. Soc. Psychol.* **78,** 524–536.
2. Camperio-Ciani, A., Corna, F. & Capiluppi, C. (2004) *Proc. R. Soc. London* **271,** 2217–2221.
3. Kendler, K. S., Thorton, L. M., Gilman, S. E. & Kessler, R. C. (2000) *Am. J. Psychiatry* **157,** 1843–1846.
4. Hamer, D. H., Hu, S., Magnuson, V. L., Hu, N. & Pattattucii, A. M. (1993) *Science* **261,** 321–327.
5. LeVay, S. (1991) *Science* **253,** 1034–1037.
6. Robinson, S. J. & Manning, J. T. (2000) *Evol. Hum. Behav.* **21,** 333–345.
7. Williams, T. J., Pepitone, M. E., Christensen, S. E., Cooke, B. M., Huberman, A. D., Breedlove, N. J., Breedlove, T. J., Jordan, C. L. & Breedlove, S. M. (2000) *Nature* **404,** 455–456.
8. Blanchard, R. & Bogaert, A. F. (1996) *Am. J. Psychiatry* **153,** 27–31.
9. Blanchard, R. & Bogaert, A. F. (1996) *Arch. Sex. Behav.* **25,** 551–579.
10. Blanchard, R. & Bogaert, A. F. (1997) *Behav. Genet.* **27,** 45–54.

11. Bogaert, A. F. (2003) *J. Pers. Soc. Psychol.* **84,** 644–652.
12. Green, R. (2000) *Psychol. Med.* **30,** 789–795.
13. Blanchard, R. (1997) *Annu. Rev. Sex Res.* **8,** 27–67.
14. Bogaert, A. F. (1997) *Behav. Neurosci.* **111,** 1395–1397.
15. Bem, D. J. (1996) *Psychol. Rev.* **103,** 320–335.
16. Sulloway, F. J. (1996) *Born to Rebel: Birth Order, Family Dynamics, and Creative Lives* (Pantheon Books, New York).
17. Blanchard, R. & Bogaert, A. F. (2004) *Am. J. Human Biol.* **16,** 151–157.
18. Blanchard, R. & Klassen, P. (1997) *J. Theor. Biol.* **185,** 373–378.
19. Ellis, L. & Ames, M. A. (1987) *Psychol. Bull.* **101,** 233–258.
20. MacCulloch, M. J. & Waddington, J. L. (1981) *Br. J. Psychiatry* **139,** 341–345.
21. Gaultieri, T. & Hicks, R. E. (1985) *Behav. Brain Sci.* **8,** 427–441.
22. Blanchard, R. (2001) *Horm. Behav.* **40,** 105–114.
23. Blanchard, R. & Bogaert, A. F. (1997) *Am. J. Psychiatry* **154,** 137.
24. Ward, I. L. (1992) in *Handbook of Behavioral Neurobiology: Sexual Differentiation*, eds. Gerail, A. A., Moltz, H. & Ward, I. L. (Plenum, New York).
25. Ward, I. L. & Weisz, J. (1980) *Science* **207,** 328–329.
26. Ellis, L. & Cole-Harding, S. (2004) *Physiol. Behav.* **74,** 213–226.