



# Etiology of male sexual orientation in an Australian twin sample

K.M. Kirk  
*University of Queensland*

---

J.M. Bailey  
*Northwestern University, Evanston, IL*

---

N.G. Martin  
*Queensland Institute of Medical Research*

---

## Abstract

Previous studies investigating the etiology of male homosexuality have found evidence for familial aggregation of male homosexuality. However, most of these have used highly selected samples, leading to the possibility that the results obtained are due to volunteer biases. The data analysed here consist of anonymous responses to a questionnaire on sexual behaviour and attitudes obtained from a large community-based sample of Australian male twins aged 18–52. Significant heritabilities were observed for a range of psychological and behavioural measures (orientation of present sexual feelings and fantasies, ever having been sexually attracted to a man, attitude to homosexual sex, number of male and female sexual partners), with approximately 42 to 60 per cent of observed variance estimated to be due to genetic influences in these variables. Familial aggregation was also observed in other measures (sexual behaviour in the past twelve months, attitude to heterosexual sex) but it was not possible to determine whether this was due to genetic or shared environmental influences.

**Keywords:** sexual orientation, twins, homosexuality

## Introduction

Familial aggregation of male homosexuality has been demonstrated in many studies of sexual orientation (Pillard and Weinrich 1986; Bailey and Bell 1993), with twin, sibling and adoption studies suggesting that this is due primarily to genetic rather than shared environmental influences (Bailey and Pillard 1991; Pillard and Bailey 1998). The majority of twin studies in this field have recruited probands via homosexual-oriented publications and organizations, which can lead to the sample being unrepresentative in important respects (Bailey, Dunne and Martin 2000) and consequently affecting twin concordances and heritability estimates (Kendler and Eaves 1989).

The current study uses a large population-based sample of Australian twins recruited from the NHMRC Australian Twin Registry, and as such reduces the volunteer biases inherent in the recruitment procedures of other studies. Previous analyses of data from this study have focused on the analysis of aggregate sexual orientation scores (Bailey et al. 2000; Gangestad, Bailey and Martin 2000), or used multivariate techniques to perform a joint analysis of several measures of sexual orientation (Kirk, Bailey, Dunne and Martin, *in press*). In this paper a variety of measures are analysed separately to consider the genetic and environmental influences on both psychological and behavioural sexual orientation in a community-based sample of Australian male twins.

## Methods

Twins for this study were drawn from the Australian National Health and Medical Research Council Twin Registry (ATR), which is a volunteer registry begun in 1978 and with about 25,000 pairs of twins of all types and ages enrolled and in various stages of active contact. Subjects for this study were recruited from a partly longitudinal twin-family study of alcohol use and abuse, and were aged between 18 and 54 at the time of participation. Since no additional selection criteria were applied, the sample from which the participants were drawn is generally representative of the Australian population in terms of personality (Jardine, Martin and Henderson 1984) and alcohol consumption (Jardine and Martin 1984), although there is a slightly disproportionate number of people with higher than average levels of education (Baker, Treloar, Reynolds, Heath and Martin 1996). Diversity within the sample in terms of religious affiliations, income and social attitudes has been documented elsewhere (Martin et al. 1986; Eaves, Martin and Heath 1990; Miller, Mulvey and Martin 1995).

In order to protect anonymity, we asked twins to return questionnaires without identifying information, and consent forms were returned separately from the questionnaires. However, correct pairing of twins' forms is

essential for genetic analysis of the data, so each twin arranged with their co-twin a common ten-digit number which could be used to pair the questionnaires. In all other respects, prospective participants were exhorted to keep the contents of the questionnaire and their responses private. Full details of the administration of the questionnaire are published elsewhere (Bailey et al. 2000; Kirk et al., in press), along with more detailed descriptions of the sample (Dunne et al. 1997).

### ***Zygoty***

Zygoty of twins was established during their participation in the previous study from which this sample was drawn, on the basis of their responses to standard items about physical similarity and being mistaken for each other. This procedure has been shown to be at least 95 per cent accurate when judged against genotyping results (Martin and Martin 1975; Kasriel and Eaves 1976; Ooki, Yamada, Asaka and Hayakawa 1990), and was further improved on by selecting for further investigation any pair whose answers were not completely consistent. In order to make use of the information from the previous study, the zygoty diagnosis was pre-marked on the anonymous questionnaire forms prior to mailing.

### ***Measures of sexual orientation***

Ten items pertaining to psychological and behavioural sexual orientation were included in the questionnaire.

- Which of the following describes your sexual feelings at present? (Attracted to women only, never to men/almost always attracted to women but on rare occasions attracted to men/more often attracted to women, but frequently find men attractive/ equally attracted to women and men/more often attracted to men, but frequently find women attractive/almost always attracted to men, but on rare occasions attracted to women/attracted to men only, never to women)
- Which of the following describes your sexual behaviour during the past year? (All sexual partners have been women/almost all sexual partners have been women, but have had sex with a man/most sexual partners have been women but have had sex with several men/have had sex with an equal number of women and men/most sexual partners have been men but have had sex with several women/almost all partners have been men but have had sex with a woman/have only had sex with men/have not had sex with anyone)
- When you have sexual fantasies, at present, is the person you imagine interacting with: (Always a woman, never a man/almost always a woman,

but on rare occasions imagine sex with a man/more often a woman, but frequently fantasize about having sex with a man/equally often a woman or a man/more often a man, but frequently fantasize about having sex with a woman/almost always a man, but on rare occasions imagine sex with a woman/always a man, never a woman/do not have sexual fantasies).

- Do you consider yourself to be: (heterosexual (straight), bisexual or homosexual (gay))?
- Have you ever been sexually attracted to a female? (yes/no)
- Have you ever been sexually attracted to a male? (yes/ no)
- In general do you find the idea of having sex with women: (very sexually exciting/somewhat exciting/neutral/slightly unpleasant/disgusting)?
- In general do you find the idea of having sex with men: (very sexually exciting/somewhat exciting/neutral/slightly unpleasant/disgusting)?
- During your entire life, approximately how many women have you had sexual contact with? (none/1 only/2/3–5/6–10/11–20/21–50/over 50)
- During your entire life, approximately how many men have you had sexual contact with? (none/1 only/2/3–5/6–10/11–20/21–50/over 50)

For the purposes of determining number of sexual partners, 'sexual contact' was defined on the questionnaire as any activity which made the respondent sexually excited, and in which their genitals made contact with any part of the other person.

### ***Statistical methods***

The variables analysed in this study are categorical, and have been analysed as ordinal data. Polychoric correlations between variables are calculated on the assumption that underlying each variable is a continuum of liability which is normally distributed in the population, and upon which thresholds delimiting the various categories are placed. However, while significant twin correlations may establish the fact that there is familial aggregation for the measures of interest, they do not distinguish between the possible mechanisms by which this arises. Potential sources of variation include three (additive genetic 'A', non-additive genetic 'D' and shared environment 'C') which make family members more alike than random individuals, and one (unique environment 'E') which introduces differences between family members. Structural equation modelling is used to determine which combination of effects provides the most parsimonious explanation for the observed pattern of MZ and DZ twin correlations, with the limitation that shared environmental and non-additive genetic effects are generally confounded in studies of twins reared together. For example, a much greater resemblance of MZ twins than DZ twins for a given trait of interest indicates

the presence of genetic influences on that trait, since DZ twins share on average only half their genes and MZ twins are genetically identical. By contrast, an absence of genetic influences would be indicated by the degree of similarity between MZ twins being the same as the degree of similarity between DZ twins. Analyses were conducted using maximum likelihood methods for raw ordinal data in Mx 1.47c (Neale 1999).

## Results

Of the 1,824 male respondents to the questionnaire, 1,682 (93.8 per cent) rated themselves as heterosexual, with 57 (3.2 per cent) considering themselves bisexual, and 55 (3.1 per cent) considering themselves as homosexual. Some non-heterosexual feelings, behaviour and fantasies at present were reported by 11.5, 3.9 and 10.7 per cent of male participants, respectively, while 14.8 per cent of the sample had had one or more same-sex partners. A small but statistically significant correlation with age was observed only for attraction to the opposite sex ( $r = 0.15$ ). Full details of the response frequencies for the ten sexual behaviour and attitudes measures are summarized elsewhere (Kirk et al., in press).

Comparison of response items of twins whose co-twin also responded to the survey versus those whose co-twin did not respond can provide an estimate of the volunteer biases affecting the individual items, provided that the same encouragement to participate has been given to individuals regardless of the participation status of their relatives (Neale and Eaves 1993). Number of opposite-sex partners was the only measure for which such a bias was detected, with partners whose co-twins did not respond to the questionnaire recording more responses in the higher categories ( $p < 0.001$ ). This would tend to indicate that this type of volunteer bias has not significantly affected the results of this study.

Polychoric correlations between twins for the ten measures of sexual behaviour, feelings and attitudes are shown in Table 1. Significant monozygotic twin correlations were observed for sexual feelings, behaviour and fantasies, ever having been sexually attracted to a man, attitude to sex with a man, and the lifetime numbers of both male and female sexual partners, indicating significant familial effects. By contrast, self-rating of sexual orientation (heterosexual, bisexual or homosexual), ever having been sexually attracted to a woman and attitude to heterosexual sex did not demonstrate significant familial effects.

Results of univariate structural equation modelling for each of the ten variables are shown in Table 2. Since the DZ twin correlation is less than half the MZ correlation for many of the variables, we fitted ADE models (incorporating additive and non-additive genetic and non-shared environmental effects). Non-zero values of A and/or D were estimated for a number

*Table 1* Polychoric correlations for sexual orientation measures for MZ and DZ male twin pairs, with 95% confidence intervals

|                           | Correlations          |                       | Number of pairs |     |
|---------------------------|-----------------------|-----------------------|-----------------|-----|
|                           | $r_{MZ}$              | $r_{DZ}$              | MZ              | DZ  |
| Feelings                  | 0.46<br>(0.23–0.65)   | 0.14<br>(–0.20–0.47)  | 309             | 184 |
| Behaviour                 | 0.44<br>(0.04–0.74)   | 0.52<br>(–0.19–0.88)  | 277             | 172 |
| Fantasies                 | 0.47<br>(0.24–0.66)   | –0.24<br>(–0.70–0.27) | 306             | 178 |
| Orientation               | 0.29<br>(–0.07–0.59)  | –0.92<br>(–1.00–0.36) | 308             | 183 |
| Attraction to women       | –0.93<br>(–1.00–0.60) | –0.15<br>(–1.00–0.90) | 311             | 184 |
| Attraction to men         | 0.56<br>(0.32–0.75)   | 0.19<br>(–0.16–0.51)  | 307             | 182 |
| Idea of sex with women    | 0.21<br>(–0.04–0.44)  | 0.26<br>(–0.09–0.54)  | 310             | 184 |
| Idea of sex with men      | 0.44<br>(0.26–0.59)   | 0.09<br>(–0.17–0.34)  | 309             | 182 |
| Number of female partners | 0.60<br>(0.53–0.67)   | 0.31<br>(0.16–0.45)   | 308             | 182 |
| Number of male partners   | 0.44<br>(0.21–0.62)   | 0.16<br>(–0.16–0.45)  | 310             | 181 |

of measures, but in most cases (with the exception of the variable measuring number of female sexual partners) neither was significant because of the strong negative correlation between the two estimates (–0.95). For this reason, very large twin samples are required to obtain significant estimates of even very large amounts of dominance (Martin, Eaves, Kearsley and Davies 1978). It is important to note, however, that the joint estimate of genetic variance (A+D) is highly significant for a number of variables (sexual feelings, sexual fantasies, ever sexually attracted to a man, attitude to sex with men, number of male and female sexual partners), with broad heritability estimates ranging from 0.42 to 0.60. That is, approximately 42 to 60 per

*Table 2* Proportions of variance attributable to additive genetic (A), non-additive genetic (D), shared environmental (C) and unique environmental (E) effects, with 95% confidence intervals.

|                           | A                   | D                   | A+D                 | C                   | E                   |
|---------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| Feelings                  | 0.08<br>(0.00–0.63) | 0.38<br>(0.00–0.65) | 0.46<br>(0.23–0.65) | –                   | 0.54<br>(0.35–0.77) |
| Behaviour                 | 0.00<br>(0.00–0.73) | –                   | 0.00<br>(0.00–0.73) | 0.46<br>(0.00–0.72) | 0.54<br>(0.26–0.89) |
| Fantasies                 | 0.00<br>(0.00–0.59) | 0.46<br>(0.00–0.65) | 0.46<br>(0.22–0.65) | –                   | 0.54<br>(0.35–0.78) |
| Orientation               | 0.00<br>(0.00–0.54) | 0.27<br>(0.00–0.58) | 0.27<br>(0.00–0.58) | –                   | 0.73<br>(0.42–1.00) |
| Attraction to women       | 0.00<br>(0.00–0.57) | 0.00<br>(0.00–0.58) | 0.00<br>(0.00–0.58) | –                   | 1.00<br>(0.42–1.00) |
| Attraction to men         | 0.19<br>(0.00–0.73) | 0.38<br>(0.00–0.75) | 0.57<br>(0.33–0.76) | –                   | 0.43<br>(0.24–0.67) |
| Idea of sex with women    | 0.00<br>(0.00–0.44) | –                   | 0.00<br>(0.00–0.44) | 0.23<br>(0.00–0.41) | 0.77<br>(0.55–0.97) |
| Idea of sex with men      | 0.37<br>(0.00–0.56) | 0.05<br>(0.00–0.60) | 0.42<br>(0.24–0.60) | –                   | 0.58<br>(0.40–0.75) |
| Number of female partners | 0.60<br>(0.02–0.67) | 0.00<br>(0.00–0.59) | 0.60<br>(0.53–0.67) | –                   | 0.40<br>(0.33–0.47) |
| Number of male partners   | 0.19<br>(0.00–0.61) | 0.26<br>(0.00–0.62) | 0.44<br>(0.22–0.63) | –                   | 0.56<br>(0.37–0.78) |

cent of observed variance in these variables appears to be due to genetic influences.

Sexual behaviour in the past year and attitude to sex with women are the only variables for which possible shared environmental influences were detected. However, the confidence intervals were extremely wide for all parameters in both models, and it is not possible to determine whether the familial effects observed are due to additive genetic or shared environmental influences. Ever having been sexually attracted to a woman only demonstrated non-shared environmental effects, indicating no evidence of familial aggregation.

## Discussion

Analysis of a number of measures relating to psychological and behavioural sexual orientation have demonstrated significant familial aggregation. In particular, Kinsey-scale measures of present sexual feelings and fantasies, ever having been sexually attracted to another man and attitude to homosexual sex were all found to be significantly influenced by genetic effects, as were numbers of both male and female sexual partners. For other measures, (sexual behaviour in the past twelve months, attitude towards sex with women), however, structural equation modelling was unable to determine whether familial aggregation was due to shared environmental or genetic influences. Ever having been sexually attracted to a woman was not found to have any familial aggregation in this sample. This finding is not unexpected given that the 'yes' response to this item was endorsed by virtually all the male study participants (96.3 per cent).

While genetic influences were found to be significant in this sample for a number of psychological and behavioural measures of sexual orientation, this was not the case for self-reported sexual orientation. One possible reason for this is that the classes used to describe sexual orientation in this way (heterosexual, bisexual or homosexual) are not interpreted consistently by all study participants: individuals with identical responses on all measures of psychological and behavioural sexual orientation have responded differently to the item asking them which sexual orientation classification they identify with. This acts to increase the measurement error, and therefore decrease the power to detect significant familial effects for this measure.

The principal advantages of this study are twofold: first, this study uses a community-based sample of twins, and therefore it reduces volunteer biases when compared to those inherent in a number of previous studies of homosexuality that used different recruitment procedures. We have also been able to estimate the degree of volunteer biases in the individual items analysed, finding a significant effect only for the self-reported number of *opposite-sex* partners. Second, it has been possible to analyse independently



a variety of measures of psychological and behavioural sexual orientation and obtain similar results – statistically significant evidence for a partly genetic etiology for male sexual orientation.

While our community-based survey should greatly reduce volunteer bias compared with previous studies which have recruited through homosexual-oriented publications and organizations, it is still possible that we have some volunteer bias. Our prevalence estimate of homosexuality (3.1 per cent) is a little higher than other population surveys in Britain (1.0 per cent: Wellings, Wadsworth and Johnson 1994) and Australia (1.8 per cent: Purdie et al., unpublished) which report prevalences closer to 1 per cent. Another consideration is that although our study is much larger than others, the low prevalence of homosexuality results in a small number of cases. As a result, our power to detect familial aggregation and to distinguish between additive genetic and shared environmental influences is low for most items. This is why previous analyses of these data have focused on composite measures (Bailey et al. 2000) or multivariate analyses (Kirk et al., in press). Finally, the evidence for genetic influence on sexual orientation might have been generated by some idiosyncratic bias whereby MZ pairs concordant for homosexuality were more likely to participate than concordant DZ males. However, it is hard to reconcile this potential bias, or other potential biases, with the almost identical prevalences of self-report homosexuality and other item responses in MZ and DZ twins, and in complete and incomplete pairs.

It is unfortunate that although our study provides quantitative evidence for genetic influence on homosexuality, it cannot ever contribute to the debate about the possible existence of an X-linked gene influencing sexual orientation (Hamer, Hu, Magnuson, Hu and Pattatucci 1993; Rice, Anderson, Risch and Ebers 1999). Neither can it address the vexed evolutionary question of how genetic variance for a trait which must be under intense selective pressure can exist to such an apparently large extent (Fisher 1958).

### **Acknowledgements**

This research was funded by a First Award to JMB from the US National Institute of Mental Health (USA) and a small Commonwealth AIDS Research Grant to NGM. Twins participating in this study were drawn from the Australian NHMRC Twin Registry. We thank John Pearson for data management and Olivia Zheng, Ann Eldridge, Sue Mason and Theresa Pangan for their work in administering the questionnaire.

### Address for correspondence

Dr K.M. Kirk, Queensland Institute of Medical Research, Post Office, Royal Brisbane Hospital, Brisbane QLD 4029, Australia. Fax: +61 7 3362 0101. E-mail: kathE@qimr.edu.au

### References

- Bailey, J.M. and Bell, A.P. (1993) 'Familiality of female and male homosexuality', *Behaviour Genetics* 23: 313–22.
- Bailey, J.M. and Pillard, R.C. (1991) 'A genetic study of male sexual orientation', *Archives of General Psychiatry* 48: 1089–96.
- Bailey, J.M., Dunne, M.P. and Martin, N.G. (2000) 'Genetic and environmental influences on sexual orientation and its correlates in an Australian twin sample', *Journal of Personality and Social Psychology* 78: 524–36.
- Baker, L.A., Treloar, S.A., Reynolds, C., Heath, A.C. and Martin, N.G. (1996) 'Genetics of educational attainment in Australian twins: sex differences and secular changes', *Behaviour Genetics* 26: 89–102.
- Dunne, M.P., Martin, N.G., Bailey, J.M., Heath, A.C., Bucholz, K.K., Madden, P.A. and Statham, D.J. (1997) 'Participation bias in a sexuality survey: psychological and behavioural characteristics of responders and non-responders', *International Journal of Epidemiology* 26: 844–54.
- Eaves, L.J., Martin, N.G. and Heath, A.C. (1990) 'Religious affiliation in twins and their parents: testing a model of cultural inheritance', *Behaviour Genetics* 20: 1–21.
- Fisher, R.A. (1958) *The Genetical Theory of Natural Selection*, New York: Dover.
- Gangestad, S.W., Bailey, J.M. and Martin, N.G. (2000) 'Taxometric analyses of sexual orientation and gender identity', *Journal of Personality and Social Psychology* 78: 1109–21.
- Hamer, D.H., Hu, S., Magnuson, V.L., Hu, N. and Pattatucci, A.M. (1993) 'A linkage between DNA markers on the X chromosome and male sexual orientation', *Science* 261: 321–7.
- Jardine, R. and Martin, N.G. (1984) 'Causes of variation in drinking habits in a large twin sample', *Acta Geneticae Medicae et Gemellologiae* 33: 435–50.
- Jardine, R., Martin, N.G. and Henderson, A.S. (1984) 'Genetic covariation between neuroticism and the symptoms of anxiety and depression', *Genetic Epidemiology* 1: 89–107.
- Kasriel, J. and Eaves, L.J. (1976) 'A comparison of the accuracy of written questionnaires with blood-typing for diagnosing zygosity in twins', *Journal of Biosocial Science* 8: 263–6.
- Kendler, K.S. and Eaves, L.J. (1989) 'The estimation of probandwise concordance in twins: the effects of unequal ascertainment', *Acta Geneticae Medicae et Gemellologiae* 38: 253–70.
- Kirk, K.M., Bailey, J.M., Dunne, M.P. and Martin, N.G. (in press) 'Measurement models for sexual orientation in a community twin sample', *Behaviour Genetics* 30(4).

- Martin, N.G. and Martin, P.G. (1975) 'The inheritance of scholastic abilities in a sample of twins. I. Ascertainment of the sample and diagnosis of zygosity', *Annals of Human Genetics* 39: 213–18.
- Martin, N.G., Eaves, L.J., Kearsley, M.J. and Davies, P. (1978) 'The power of the classical twin study', *Heredity* 40: 97–116.
- Martin, N.G., Eaves, L.J., Heath, A.C., Jardine, R., Feingold, L.M. and Eysenck, H.J. (1986) 'Transmission of social attitudes', *Proceedings of the National Academy of Sciences* 83: 4364–8.
- Miller, P., Mulvey, C. and Martin, N.G. (1995) 'What do twins studies reveal about the economic returns to education? A comparison of Australian and US findings', *American Economic Review* 85: 586–99.
- Neale, M.C. (1999) *Mx: Statistical Modelling*, 4th edn, Department of Psychiatry, Medical College of Virginia, VA.
- Neale, M.C. and Eaves, L.J. (1993) 'Estimating and controlling for the effects of volunteer bias with pairs of relatives', *Behaviour Genetics* 24: 239–58.
- Ooki, S., Yamada, K., Asaka, A. and Hayakawa, K. (1990) 'Zygosity diagnosis of twins by questionnaire', *Acta Geneticae Medicae et Gemellogicae* 39: 109–15.
- Pillard, R.C. and Bailey, J.M. (1998) 'Human sexual orientation has a heritable component', *Human Biology* 70: 347–65.
- Pillard, R.C. and Weinrich, J.D. (1986) 'Evidence of familial nature of male homosexuality', *Archives of General Psychiatry* 43: 808–12.
- Rice, G., Anderson, C., Risch, N. and Ebers, G. (1999) 'Male homosexuality: absence of linkage to microsatellite markers at Xq28', *Science* 284: 665–7.
- Wellings, K., Wadsworth, J. and Johnson, A. (1994) 'Sexual diversity and homosexual behaviour', in K. Wellings, J. Field, A. Johnson and J. Wadsworth (eds), *Sexual Behaviour in Britain*, London: Penguin, pp. 178–229.