Developmental Psychology

Early Life Conditions and Adolescent Sexual Orientation: A Prospective Birth Cohort Study

Yin Xu, Sam Norton, and Qazi Rahman

Online First Publication, February 14, 2019. http://dx.doi.org/10.1037/dev0000704

CITATION

Xu, Y., Norton, S., & Rahman, Q. (2019, February 14). Early Life Conditions and Adolescent Sexual Orientation: A Prospective Birth Cohort Study. *Developmental Psychology*. Advance online publication. http://dx.doi.org/10.1037/dev0000704

AMERICAN PSYCHOLOGICAL ASSOCIATION

Developmental Psychology

© 2019 American Psychological Association
0012-1649/19/$12.00

http://dx.doi.org/10.1037/dev0000704

Early Life Conditions and Adolescent Sexual Orientation: A Prospective Birth Cohort Study

Yin Xu, Sam Norton, and Qazi Rahman
King's College London

This study tested the association between multiple prenatal and postnatal early life factors and adolescent sexual orientation in a longitudinal birth cohort. Factors included birth weight, gestational age, parental age at birth, number of older brothers and sisters, breastfeeding, maternal anxiety/depression, family socioeconomic position, parent–child relationships, parental absences, pubertal body mass index, and housing issues. We used data on 5,007 youth from the Avon Longitudinal Study of Parents and Children (ALSPAC). Sexual orientation was assessed using a 5-point scale of sexual attraction at 15.5 years. Early life factors were separated into three developmental periods: prenatal ($n = 9$), before 7 years ($n = 5$), and after 7 years ($n = 5$). We controlled for childhood gender nonconformity, handedness, and digit ratio as markers of prenatal androgen exposure. Gender nonconformity was strongly associated with later male and female nonheterosexuality, and higher right-hand digit ratio was associated with later male nonheterosexuality. Boys with low birth weight and shorter breastfeeding duration were more likely to have a later nonheterosexual orientation. Boys with parental absence before 7 years of age were more likely to be nonheterosexual, but this effect disappeared after entering all early life history factors. Parental absence since birth, low prenatal family socioeconomic position, and poorer parent–child relationship were associated with later nonheterosexuality among girls. The results are discussed in the context of a life history framework for understanding human sexual orientation development in males and females.

Keywords: life history, sexual orientation, birth weight, gender nonconformity, ALSPAC

Supplemental materials: http://dx.doi.org/10.1037/dev0000704.supp

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

Human sexual orientation is likely to be multifactorial in its origins. Biological and psychosocial factors may influence the life course of sexual orientation (affecting sexual attractions, identity, and sexual behaviors differently; Bailey et al., 2016). This is consistent with multifactorial influences on other developmental traits such as personality. However, scholars often imply multiple influences on sexual orientation but rarely, if ever, test them. Research suggests that genetic factors explains approximately one third of the variation in sexual orientation (Bailey et al., 2016). Thus, most of the differences between people in their sexual orientation are due to environmental factors (often nonshared) pointing to multiple etiology. Causal pathways are rarely tested in prior research because of the use of cross-sectional designs, surveys of adult heterosexuals and nonheterosexuals which are susceptible to reporting biases, and problems accounting for dependencies in data (Bailey et al., 2016). Few data sets lend themselves to testing a range of biological and psychosocial variables. We therefore examined the role of multiple prenatal and postnatal early life factors on the development of adolescent sexual orientation in a longitudinal, birth cohort from England.

Yin Xu, Sam Norton, and Qazi Rahman, Department of Psychology, Institute of Psychiatry Psychology & Neuroscience, King's College London.

The authors are extremely grateful to all the families who took part in this study, the midwives for their help in recruiting them; and the whole ALSPAC team, which includes interviewers, computer and laboratory technicians, clerical workers, research scientists, volunteers, managers, receptionists and nurses. The U.K. Medical Research Council and the Wellcome Trust (Grant ref: 102215/2/13/2) and the University of Bristol provide core support for ALSPAC. Yin Xu is supported by a King's-China Scholarship.

Correspondence concerning this article should be addressed to Yin Xu or Qazi Rahman, Department of Psychology, Institute of Psychiatry Psychology & Neuroscience, King's College London, 5th floor Bermondsey Wing, Guys Hospital Campus, London SE1 9RT, United Kingdom. E-mail: yin.xu@kcl.ac.uk or qazi.rahman@kcl.ac.uk

Life History Theory

Life history theory aims to explain the diversity in life trajectories of organisms, especially in their reproductive histories (Del Giudice, Gangestad, & Kaplan, 2015). It can be conceived of as a "biopsychosocial" model, integrating genetic and nongenetic (e.g., socialization, environment, and learning) processes in accounting for variation in development and reproduction. In humans, this framework has focused on the influence of early life conditions (those characterized by high mortality and morbidity, environmental unpredictability, low parental investment, and resource scarcity) on sexual behavior traits across the life span. Prior research suggests that humans will adopt "fast" or "slow" sexual life history strategies according to the early environment they experience (Ellis, 2004). The fastness or slowness is often defined by the age at which reproductive or sexual behaviors begin. For example, somatic trait that appears robustly associated with sexual orientation. Nonheterosexual men and women are significantly more likely to be nonright-handed than heterosexual men and women (Lalumière, Blanchard, & Zucker, 2000).

The role of these variables in the life history framework is speculative but offer plausible hypotheses. Early life factors could promote GNCB which then cascades into later nonheterosexuality (because early life factors are causally closer to GNCB than to sexual orientation). Or GNCB, handedness, and digit ratio could have independent influences on both early life conditions and sexual orientation. Early life conditions may alter prenatal androgen exposure, and then influence later sexual orientation. Or, GNCB could act as a behavioral proxy for a common underlying mechanism, such as prenatal androgen exposure (with handedness and digit ratio acting as more direct markers; Skorska & Bogaert, 2017). As prenatal androgen theory is the dominant model of sexual orientation development, the present study examined these three indicators of androgen exposure as potential covariates.

The Present Study

Here we use data from a prospective birth cohort in England to test whether a range of early life factors (in prenatal, pre-7 years of age, and post-7 years developmental stages) were associated with adolescent sexual orientation at age 15.5 years. It appears to be appropriate to begin measuring sexual orientation at 15.5 years old. Studies also show that men and women recall first having feelings of sexual attraction at approximately age 10, on average (McClintock & Herdt, 1996). One study reported a mean age of self-reported first awareness of same-sex attraction at approximately 15 years (Calzo, Antonucci, Mays, & Cochran, 2011). Some studies report even earlier recalled mean age of awareness of same-sex attractions (e.g., Floyd & Bakeman, 2006). Changes in reported sexual orientation identity were also found to occur at a similar rate throughout adolescence and into emerging adulthood (Ott, Corliss, Wypij, Rosario, & Austin, 2011). This is the first study of its kind and includes a range of early life factors never studied before in relation to sexual orientation. The longitudinal design will permit better tests of causal pathways. Here we test the extent to which prenatal factors and postnatal early life factors predict later sexual orientation in boys and girls separately. We hypothesized that prenatal early life factors (e.g., low birth weight) would be associated with nonheterosexuality in both boys and girls, and postnatal early life factors (e.g., poorer parent–child relationship) would be associated with nonheterosexuality in girls since their sexual orientation is more socially influenced. We further controlled for the influences of GNCB, handedness, and digit ratio in our analyses.

Method

Participants

Participants were part of the Avon Longitudinal Study of Parents and Children (ALSPAC). All pregnant women with an expected date of delivery between April 1, 1991 and December 31, 1992 in the Bristol area of the South West of the United Kingdom were eligible and invited to attend the ALSPAC. The initial sample recruited 14,541 (71.81% of the eligible sample) pregnant women who delivered 14,062 live-born children and 13,988 were alive at 1 year. Additional recruitment attempting to bolster the original sample with eligible cases who had failed to join the study at the beginning resulted in 15,458 fetuses with data collected from the age of 7 onward. Of this total sample of 15,458 fetuses, 14,775 were live births and 14,701 were alive at 1 year of age. Fifty-nine percent of the cohort attended the "Teen Focus" sessions and have been followed four times between the age of 12.5 years old and 17 years old. For more details, see Boyd et al. (2013). The study website contains details of all the data, which are available through a searchable data dictionary: http://www.bris.ac.uk/alspac/researchers/data-access/data-dictionary/. Ethical approval for the study was obtained from the ALSPAC Law and Ethics Committee and the Local Research Ethics Committees, and King's College London Psychiatry, Nursing & Midwifery research ethics subcommittee (protocol reference number: LRS-16/17–4194; "Testing a Life History Approach to the Study of Variation in Human Sexual Orientation"). We analyzed ALSPAC data reported by parents and children across different time points. Adolescents who reported a valid response of sexual orientation and sexual behavior (see Supplemental Text S1 in the online supplemental material) at 15.5 years old were included here, $N = 5,007$ (2,349 boys and 2,658 girls).

Measures

Sexual orientation. At 15.5 years old, adolescents were required to answer the question: "Please choose the description that best fits how you think about yourself" on a 5-point Kinsey-like scale, ranging from 1 (*100% heterosexual*), 2 (*mostly heterosexual but also attracted to the same sex*), 3 (*bisexual*), 4 (*mostly homosexual but also attracted to the opposite sex*), 5 (*100% homosexual*), 6 (*not sexually attracted to either sex*), and 7 (*not sure*). This was done via computer to promote disclosure of sensitive personal information. Adolescents who chose "not sexually attracted to either sex" ($n = 17$) or "not sure" ($n = 91$) were excluded from the analyses. This is because we had no a priori predictions about the role of early life conditions in adolescents with ambiguous or no sexual attractions and many such adolescents identify as heterosexual later in life (Ott et al., 2011; Savin-Williams & Joyner, 2014). Such 5-point scales of sexual attractions have been used in large studies of adolescents (Austin et al., 2009; Ott et al., 2011; Remafedi, Resnick, Blum, & Harris, 1992; Saewyc, Skay, Bearinger, Blum, & Resnick, 1998). Saewyc et al. (1998) also pilot tested their items with a youth sample before full-scale implementation. The 5-point measures show good stability (i.e., test–retest over 2-year intervals) in adolescents (Ott et al., 2011), expected associations with sex of sexual partners among adolescents (Remafedi et al., 1992; Saewyc et al., 1998), and low nonresponse rates compared with measures of other components of adolescent sexual orientation (Saewyc et al., 2004). As bisexuals may differ from gay/lesbian individuals in some components of sexual orientation, we treated them as separate groups. Accordingly, adolescents who chose *100% heterosexual* or *mostly heterosexual but also attracted to the same sex* were coded as heterosexual, those who chose *bisexual* were coded as bisexual, and those who chose *mostly homosexual but also attracted to the opposite sex* or *100% homosexual* were coded as homosexual. As a result, 2,290 heterosexual boys (45.73%), 29 bisexual boys (0.58%), 30 homosexual

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

boys (0.60%), 2,585 heterosexual girls (51.63%), 56 bisexual girls (1.12%), and 17 homosexual girls (0.34%) were included.

Body size. Birthweights (kg) were taken from birth notification and/or obstetric data and/or recorded by ALSPAC measurers in the delivery room. For data recorded by more than one method, we used the following criteria. If birth weight values from each measurement method were identical, then the value was accepted; if disagreement between birth weight values from different measurement methods were less than 100 g, then the lowest value was accepted; if disagreement between birth weight values from different measurement methods were greater than 100 g, then the value was coded as missing (no observations in our sample had disagreement greater than 100 g). At 14 years and 7 months, adolescents gave their height and weight, to generate body mass index.

Gestational age. This was based on the date of mother's last menstrual period, pediatric or obstetric assessment, and ultrasound assessment. Adolescents were categorized into three gestational age groups: preterm birth (<37 weeks' gestational age), term birth (37–41 weeks' gestational age), and postterm birth (>41 weeks' gestational age; Savitz et al., 2002).

Parental age. Maternal age was recorded as the age at the last menstrual period. When adolescents were at 12 weeks' gestation, the partner of the mother was required to report whether he was the father of the child. If he reported "yes," his age at completion of questionnaire was coded as paternal age; otherwise, paternal age was coded as missing.

Maternal anxiety and depression. When adolescents were 18 weeks' gestational age and 8 weeks old, two subscales of Crown-Crisp Experiential Index (CCEI) were used to measure maternal anxiety and depression (Ross & Hafner, 1990). These have acceptable reliability and validity (Alderman, Mackay, Lucas, Spry, & Bell, 1983; Burgess, Mazzocco, & Campbell, 1987). The test–retest reliabilities over a year period were .77 and .72 for anxiety and depression, respectively (Crown, Duncan, & Howell, 1970). Patients diagnosed with anxiety disorder and depression scored very highly on corresponding CCEI subscales (Crisp, Jones, & Slater, 1978). Each subscale consists of eight items, rated on a 4-point scale from 1 (*never*) to 4 (*very often*). An example item is "Do you worry a lot?". We recoded this into four variables: prenatal maternal anxiety/depression and postnatal maternal anxiety/depression. Because prenatal maternal anxiety and depression were correlated ($r = .77$), the average of prenatal maternal anxiety and depression was used in the analysis. We did similarly for postnatal maternal anxiety and depression ($r = .73$).

Older siblings. At 6 months, adolescents' mothers reported the numbers of older brothers and older sisters who live with the adolescents, including maternal and paternal half-brothers and half-sisters, stepbrothers and stepsisters, fostered children, and adopted children.

Family structure changes. At six different points in time, adolescents' mothers answered the questions: "Is the present live-in father-figure/mother-figure the biological father/mother of the study child?" and "How old was the child when the biological father/mother stopped living with the child?". Father absence and mother absence were recoded into two variables (father absence and mother absence) with four categories: never with father/mother, father/mother absence before 7 years of age, father/mother absence since 7 years of age, and father/mother present. Because of low rates of mother absence, it was necessary to combine these variables to indicate parental absence (see missing data section).

Duration of breastfeeding. When adolescents were 1 year and 3 months old, their mothers reported whether their children were breast-fed (yes or no) and the duration of breastfeeding in months. Duration of breastfeeding in months was used in the analysis, and adolescents who were not breast-fed received a score of 0 on this variable. Maternal reports of breastfeeding initiation and duration appear accurate and reliable (Li, Scanlon, & Serdula, 2005).

House moves. At six different points in time, adolescents' mothers reported how many times they have moved home since last interview. We recoded this information into two variables: the number of house moves before 7 years of age and since 7 years of age.

Parent–child relationship. When adolescents were 9 years 7 months old, they rated their relationship with their parents on a 5-point scale ranging from 1 (*not true*) to 5 (*true*). Nine items developed by the ALSPAC study team were used. An example item is "I have a parent who I have a lot of fun with." Cronbach's alpha for the scale in our sample was .82. Exploratory factor analysis yielded one factor (eigenvalue = 3.78) accounting for 42.03% of the variance in our sample (Supplemental Table S1 in the online supplemental material). The total score of the nine items was used in the analysis, with a higher score indicating a better relationship with parents.

Family SEP. Family SEP was assessed via parents' education, parents' occupation, household income, and family financial difficulties. When adolescents were 32 weeks' gestation old, their mothers reported their own and their partner's highest educational qualifications (CSE, vocational, O level, A level, and bachelor's degree).

At six different points in time, adolescents' mothers reported their own occupation. At five different points in time, the mothers' partners reported their own occupation. The Office for National Statistics (2000) was used to categorize occupation type. We recoded this into four variables, mother's lowest occupation before adolescents were born, father's lowest occupation before adolescents were born, mother's lowest occupation before adolescents were 7 years old, and father's lowest occupation before adolescents were 7 years.

At four different points in time, adolescents' mothers also answered the question: "On average, about how much is the take-home family income each weak?" Participants were required to choose from Less than £100, £100–199, £200–299, £300–399, £400 or more, and do not know. This was recoded into two variables, lowest family income before adolescents were born, and lowest family income before adolescents were 7 years old.

At six different points in time, adolescents' mothers answered the question: "How difficult at the moment do you find it to afford these items? (e.g., food, clothing, and heating)" on a 4-point scale from 0 (*not difficult*) to 3 (*very difficult*). Five items were used to measure financial difficulties. This was recoded into three variables: the worst financial difficulties before adolescents were born, the worst financial difficulties before adolescents were 7 years old, and the worst financial difficulties since adolescents were 7 years old.

Because these indicators of family SEP are correlated (polychoric correlation from .19 to .63), summary scores incorporating these indicators were constructed: prenatal family SEP, family SEP before 7 years of age, and family SEP since 7 years of age. We applied polychoric principal component analysis and used the loadings on the first principal component as item weightings to

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

generate a summary score for each developmental stage. A higher score indicates lower family SEP (Supplemental Table S2 in the online supplemental material for factor loadings). The first component explained 49.20%, 50.27%, and 55.32% of the variation in prenatal family SEP, family SEP before 7 years of age, and family SEP since 7 years of age, respectively.

Childhood gender-nonconforming behavior. When adolescents were 2 years 6 months, 3 years 6 months, and 4 years 9 months old, mothers rated their children's gender-nonconforming behaviors (GNCB) using the Preschool Activities Inventory (PSAI; Golombok & Rust, 1993). PSAI is a validated self-report questionnaire (Golombok & Rust, 1993). PSAI also has acceptable reliability (test–retest reliability over a year = .64; split-half reliability = .88; Golombok & Rust, 1993). The PSAI consists of 12 male-typical items and 12 female-typical items assessing children's toy preferences (e.g., jewellery), activity preferences (e.g., playing at fighting), and characteristics (e.g., avoid getting dirty). Each item was rated using a 5-point scale ranging from 1 (*never*) to 5 (*very often*). The PSAI is scored via deducting the total score for female-typical items from the total score for the male-typical items, then transforming to a pseudo-*T* scale by multiplication with 1.10 and adding 48.25 (Golombok & Rust, 1993). A higher score indicates more male-typical behavior and less female-typical behavior for both girls and boys. The average of the three time points was used (GNCB at these three times significantly and consistently predicts adolescent sexual orientation; Li et al., 2017).

2D:4D digit ratio. When adolescents were 11 years old, photocopies of their hands were taken. They were required to place the ventral surface of both hands flat onto the photocopier, and the lengths of the second and the fourth digits for each hand were measured to 0.01 mm using the "Mahr digital caliper16 EX" (from tip of finger to basal crease). This method has been shown to be accurate and reliable (Ribeiro, Neave, Morais, & Manning, 2016). The digit ratio (2D:4D) was calculated as the ratio of the lengths of the second digit to the fourth digit.

Handedness. At 9 year 7 months, adolescents were asked which hand they prefer to use for six activities (e.g., "Which hand to you draw") rated from 1 = *left*, 2 = *either*, 3 = *right*, and 4 = *do not do this at all*. Cronbach's alpha for the scale in our sample was .84. Adolescents who chose *do not do this at all* were coded as missing. Higher total scores indicated greater right-handedness.

Procedure

Missing data. The variables had 2.78–56.80% missing information within the analysis sample (Table 1 and 2). These missing data were handled using multiple imputation stratified by sex. Prior to imputation, we examined the potential missing data mechanisms using logistic regression to assess whether the observed variables predict missingness. The results indicated that the data were unlikely to be missing completely at random (e.g., duration of breastfeeding and house moves before 7 years predicted the missingness of family SEP before 7 years).

For the imputation model, recommendations for longitudinal studies are that all variables in the analysis should be included (White, Royston, & Wood, 2011). Thus, the outcome variable (sexual orientation), predictors (early life conditions), covariates (e.g., GNCB), and an auxiliary variable (sexual behavior; see Supplemental Text S1 in the online supplemental material) that independently related to the outcome were included. Recommendations also instruct that the number of imputations should be at least as large as the percentage of missing data (White et al., 2011). Thus, we used 57 imputations. We used the chained equations algorithm (MICE) model since we have a combination of continuous and categorical variables. The continuous variables included in the current study were not normally distributed (Shapiro-Francia test showed that all *p*s < .001). Consequently, we used predictive mean matching since this approach makes no distributional assumption.

Imputation for mother absence failed to converge due to small cell sizes. Thus, we were forced to combine father absence and mother absence into one variable labeled *parental absence* (never with father or mother, either parent absence before 7 years, either parent absence since 7 years, and both parents presence). Trace plots and other diagnostics provided no cause for concern regarding the imputed values. Typically, sensitivity analysis comparing analyses based complete-case and imputed data would be undertaken, however, due to the proportion of missing data in the sample this was not possible.

Data analysis. All analyses were performed in Stata 15.0 and carried out separately for boys and girls. First, a univariate ordered logistic regression was estimated with sexual orientation (heterosexual, bisexual, or homosexual) regressed onto each early life variable to determine the unadjusted association. Then a three-step hierarchical multivariable ordered logistic regression was estimated with early life factors entered in sequential manner based on the age period at which they were measured and controlling for covariates (GNCB, 2D:4D digit ratio, and handedness). In the first step, prenatal early life factors (e.g., birth weight and gestational age) were entered. In the second step, early life factors before 7 years were entered. In the third step, early life factors since 7 years were entered.

Finally, we used the *mimrgns* command to calculate the average predicted probability of being homosexual for each significant early life factor and covariate in the final model generated by the third step of the multivariable ordered logistic regression. The predicted probabilities for each continuous variable were computed using its 25th/50th/75th percentile and observed values for the remaining variables in the model. We also calculated the predicted probability of being homosexual for adolescents with all the significant factors and covariates present, and for adolescents with none of these significant factors and covariates. The significant continuous variables were set to the 25th/75th percentile for present (75th for variables with odds ratios [*OR*s] greater than 1 and 25th for variables with *OR*s less than 1) and 50th percentile for absent, and the remaining variables were set to the observed values.

The ordered logistic regression analyses assume that the outcome measure is ordinal in nature and that the association between the predictor and outcome is equivalent across the levels of the outcome (proportional odds). That is, the log-*OR* for the predictor in a logistic model where the outcome is heterosexual versus bisexual/homosexual is equivalent to the log-*OR* for the model where the outcome is heterosexual/bisexual versus homosexual. The Brant test was used iteratively to assess the likelihood that this assumption held for each predictor (Brant, 1990). Where the test was significant at the 5% level the assumption was relaxed for that

Table 1 (*continued*)

Variable	Sexual orientation Heterosexual	Bisexual	Homosexual
Mother presence	2,002	27	23
Covariates			
Childhood gender nonconforming behavior[f]			
n	1,706	25	21
M (*SD*)	61.93 (7.28)	55.96 (10.30)	54.64 (7.73)
Left 2D:4D			
n	2,128	27	24
M (*SD*)	.96 (.03)	.96 (.04)	.97 (.02)
Right 2D:4D			
n	2,125	27	25
M (*SD*)	.96 (.03)	.97 (.04)	.99 (.03)
Handedness			
n	1,882	23	22
M (*SD*)	15.85 (3.13)	16.48 (1.95)	16.00 (2.79)

Note. Dashes means 5 or less. Cell counts 5 or less are not presented in order to comply with ALSPAC publication requirements.
[a] The range is from 0 to 16. [b] The range is from 0 to 15.32. [c] The range is from 0 to 16.40. [d] The range is from 0 to 12.25. [e] The range is from 9 to 45. [f] The range is from −4.55 to 101.05.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

predictor. Thus, one *OR* is presented where the proportional odds assumption held and two are presented where it did not.

Because bisexual and homosexual individuals may differ in some components of sexual orientation, it is possible that the outcome in the ordered regressions is not ordinal in nature. To assess the robustness of our estimates to varying conceptualizations of sexual orientation, we also estimated logistic regression where the outcome was heterosexual versus bisexual/homosexual, and multinomial logistic regression where the outcome was heterosexual versus bisexual and heterosexual versus homosexual. In these models no assumption is made about the outcome being ordinal or the proportionality of the odds (Supplemental Table S3–S6 in the online supplemental material.).

Although no formal power calculation was conducted, it is possible to consider power to detect a meaningful effect. At the 5% level, the sample size allows for the detection of *OR* of greater than approximately 1.8 for a binary predictor variable with 80% power, where the proportional odds assumption holds for the predictor. As such, despite the low number of nonheterosexuals in the sample, power to detect meaningful effects is acceptable.

Results

Boys

GNCB (*OR* = 0.888 to 0.902, all $ps < .001$) and right 2D:4D digit ratio (*OR* = 1.185 to 1.283, all $ps < .01$) were significantly associated with nonheterosexual orientation in both univariate and multivariable regressions, although there were no significant associations between left 2D:4D digit ratio, handedness, and sexual orientation (Table 3 and 4). When the *OR* was transformed to the percentage change in the ratio for one-unit increase in the predictor using the formula: $100 \times (OR - 1)$, the results suggested that boys who displayed more GNCB had 10.90% to 12.60% greater odds of being nonheterosexual, and boys with higher right 2D:4D digit ratio had 18.50% to 28.30% greater odds of being nonheterosexual.

Birth weight (*OR* = 0.458 to 0.570, all $ps < .05$) and duration of breastfeeding (*OR* = 0.904 to 0.921, all $ps < .05$) were strong predictors of nonheterosexual orientation in both regression models. Boys with low birth weight had 75.40% to 118.30% greater odds of being nonheterosexual, and boys with shorter duration of breastfeeding had 8.60% to 10.60% greater odds of being nonheterosexual. Greater number of older brothers (*OR* = 2.069 to 2.254, all $ps < .05$) was significantly associated with homosexual orientation in multivariable regressions, indicating that boys with greater number of older brothers had 106.90% to 125.40% greater odds of being homosexual. Greater number of house moves since 7 and parental absence before 7 years of age were also significantly associated with nonheterosexual orientation in univariate regression, but these disappeared in the multivariable regression when all early life factors were entered into the model.

To further aid understanding of the results, the significant *OR*s (relative difference) from the third step of the multivariable ordered logistic regression were transformed to average marginal effects (absolute difference). Boys who displayed more GNCB (25th percentile) had a 1.73%, 95% confidence interval (CI) = 1.10–2.36% probability of being homosexual, boys with higher right 2D:4D digit ratio (75th percentile) had a 1.65%, 95% CI = 1.02–2.29% probability of being homosexual, boys with lower birth weight (25th percentile) had a 1.57%, 95% CI = 0.99–2.16% probability of being homosexual, and boys with shorter duration of breastfeeding (25th percentile) had a 1.80%, 95% CI = 1.08–2.51% probability of being homosexual. Boys with more GNCB, higher right 2D:4D digit ratio, lower birth weight, and shorter duration of breastfeeding had a 3.74%, 95% CI = 2.00–5.49%, probability of being homosexual, while boys with none of these had a 0.78%, 95%CI = 0.36–1.20% probability of being homosexual (see Figure 1).

Girls

Consistent with the results for boys, GNCB was a strong predictor of nonheterosexual orientation among girls in both regression models, with *ORs* ranging from 1.072 to 1.097, all $ps < .01$,

Table 2 (*continued*)

Variable	Sexual orientation: Heterosexual	Bisexual	Homosexual
Mother presence	2,215	44	11
Covariates			
Childhood gender nonconforming behavior[f]			
n	1,857	33	14
M (*SD*)	37.50 (7.74)	41.71 (9.63)	45.63 (9.60)
Left 2D:4D			
n	2,355	50	14
M (*SD*)	.97 (.03)	.97 (.03)	.96 (.02)
Right 2D:4D			
n	2,359	50	14
M (*SD*)	.97 (.03)	.97 (.03)	.96 (.02)
Handedness			
n	2,172	35	12
M (*SD*)	15.93 (2.84)	15.57 (3.01)	15.58 (2.75)

Note. Dashes means 5 or less. Cell counts 5 or less are not presented in order to comply with Avon Longitudinal Study of Parents and Children (ALSPAC) publication requirements.
[a] The range is from 0 to 16. [b] The range is from 0 to 15.32. [c] The range is from 0 to 16.40. [d] The range is from 0 to 12.25. [e] The range is from 9 to 45. [f] The range is from −4.55 to 101.05.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

indicating that girls who displayed more GNCB had 7.20% to 9.70% greater odds of being nonheterosexual. There were no significant associations between left or right 2D:4D digit ratios, handedness, and sexual orientation (Table 3 and 5).

Low prenatal family SEP ($OR = 1.110$ to 1.343, all $ps < .05$), parental absence since birth ($OR = 2.501$ to 4.494, all $ps < .05$), and poorer reported relationship with parents ($OR = 0.928$ to 0.931, all $ps < .05$) were also significantly associated with nonheterosexuality in both regression models. These indicated that girls with a low prenatal family SEP had 11.00% to 34.30% greater odds of being nonheterosexual, girls with parental absence since birth had 150.10% to 349.40% greater odds of being nonheterosexual, and girls with a more negative relationship with parents had 7.40% to 7.80% greater odds of being nonheterosexual.

In terms of average marginal effects, girls who displayed more GNCB (75th percentile) had a 0.74%, 95% CI = 0.38–1.10% probability of being homosexual, girls with low prenatal family SEP (75th percentile) had a 1.24%, 95% CI = 0.35–2.12% probability of being homosexual, girls with parental absence before 7 had a 1.35%, 95% CI = 0.35–2.35% probability of being homosexual, and girls with poorer reported relationship with parents (25th percentile) had a 0.65%, 95% CI = 0.34–0.96% probability of being homosexual. The predicted probability of being homosexual for girls with more GNCB, low prenatal family SEP, parental absence before 7, and poorer reported relationship with parents was 3.36%, 95% CI = 0.03–6.69%, whereas girls with none of these had a 0.29%, 95%CI = 0.09–0.49% probability of being homosexual (Figure 2 and 3).

Discussion

This study in a prospective birth cohort produced three main findings. First, boys with low birth weight and shorter duration of breastfeeding were more likely to be nonheterosexual (bisexual and homosexual), and boys with greater number of older brothers were more likely to be homosexual. Second, boys with parental absence before 7 were more likely to be nonheterosexual, but this association disappeared after entering all early life factors into the statistical models. Finally, parental absence since birth, low prenatal family SEP, and low parent–child relationship scores predicted nonheterosexual orientation among girls. These results were found while controlling for GNCB, handedness, and 2D:4D digit ratio.

Early Life Conditions and Sexual Orientation in Boys

The findings regarding birth weight and older brothers is consistent with prior work in cross-sectional samples (Blanchard, 2018; Skorska et al., 2017). However, caution must be exercised in interpreting these findings. The number of older brothers in the present cohort included half-brothers, stepbrothers, fostered brothers, and adopted brothers. The maternal immunity theory behind the FBO effect predicts that only previously carried biological male siblings should increase the probability of homosexuality of later born male fetuses (Bogaert, 2006). The birth weight findings support growing evidence showing low birth weight predicts faster sexual life history (Nettle et al., 2011). In addition, low birth weight among later nonheterosexual boys offers support for maternal immunity hypothesis linking birth weight and FBO (although here we find those two effects to be independent; Blanchard, 2012). None of the early life conditions since boys were 7 years were significantly related to sexual orientation in the multivariate regressions, adding further support to the importance of the prenatal or early postnatal developmental period for male sexuality (Xu et al., 2018).

The association between breastfeeding duration and male nonheterosexuality is novel. Low breastfeeding duration may be related to birth weight, although the direction reported here is opposite to what is typically found (low birth weight infants usually receive more breastfeeding as per medical advice). At this stage, the link between breastfeeding and male sexual orientation is unclear but does potentially indicate lower maternal somatic investment in later nonheterosexual boys. Trade-offs underlying breastfeeding decisions (physiological as well as behavioral) by sured genetic and environmental confounds that load simultaneously on early life conditions, our covariates, and sexual orientation (Barbaro et al., 2017). This requires further study. Maternal reports of some of the early life factors may either under- or overestimate their prevalence among adolescents who later become nonheterosexual. For example, mothers with gender nonconforming children could engage in less parental investment (indexed by factors such duration of breastfeeding, parent–child relationships, and so on), which is then associated with later nonheterosexuality. There is growing evidence that gender nonconforming children experience negative reactions and greater stigmatization from family and peers and so this possibility requires further study.

The nature of the cohort meant that several early life factors could not be simultaneously measured in all three developmental periods. Some of the measures of early life conditions (e.g., family SEP) may also act as mediators between other conditions and later sexual orientation. SEP, because of its close association with growing up in a resource rich or poor context, requires careful study. As does the link between birth weight and duration of breastfeeding. In addition, of the 17 early life factors two (parental absence and gestational age) had restricted response categories which may have reduced power. For some of these measures, validity and reliability information was not available.

The sample sizes of nonheterosexual boys and girls were small, especially homosexual girls. The rates for gestational age and parental absence were low and were not observed in one or more of the groups. Thus, a small increase in the number of nonheterosexual boys/girls who experienced parental absence, or were preterm birth, will result in larger *OR*s. However, given the low prevalence of nonheterosexual orientation among the population, small numbers of nonheterosexuals in longitudinal or other cohort studies are to be expected. Despite the small number of nonheterosexuals, the power to detect meaningful effects was acceptable because of the large overall size of the sample. The use of ordered regression models improves precision gains for the *OR*s, particularly where some groups are small (or where there are many categories) because one can carry over power from the larger groups to the smaller ones. Although case-control studies would afford greater power this would come at the cost of associated biases.

The current study measured sexual orientation when adolescents were 15.5 years of age. Prior research found that the number of people who identified themselves as nonheterosexual increases from adolescence to adulthood (Austin et al., 2009). Thus, it is possible that adolescents may change their sexual orientation reports if we reassess our cohort at later ages, which may even produce somewhat different results. Adolescents may also misreport their sexual orientation (Savin-Williams & Joyner, 2014). Future studies must investigate such cohorts at later ages and model any change in sexual orientation outcomes and their impact on model estimates. The use of a single-item measure of sexual orientation is also a limitation. Future studies should aim to measure several components of sexual orientation (e.g., identity, attractions, and behavior) or more fully explore the reliability and validity of single-item measures over several time points during adolescence and young adulthood.

Conclusion

The results offer support to the hypothesis that early life factors influence sexual orientation in adolescent boys and girls. The developmental stage of these factors appears important to sex differences in adolescent sexual orientation. Among boys, prenatal and early life conditions before 7 years of age predicted later sexual orientation. Among girls, a mix of factors measured prenatally and later in childhood predicted later sexual orientation. These associations were found while controlling for putative markers of prenatal androgen influence. GNCB was a strong predictor of sexual orientation as previously shown. Note the role of those influences that could also be conceptualized as "psychosocial" appears small across the board. Future longitudinal studies should test for the role of possible third variables (or genetic confounds), which may act of mediators for the associations found here.

References

Alanko, K., Santtila, P., Harlaar, N., Witting, K., Varjonen, M., Jern, P., . . . Sandnabba, N. K. (2010). Common genetic effects of gender atypical behavior in childhood and sexual orientation in adulthood: A study of Finnish twins. *Archives of Sexual Behavior, 39,* 81–92. http://dx.doi.org/10.1007/s10508-008-9457-3

Alderman, K. J., Mackay, C. J., Lucas, E. G., Spry, W. B., & Bell, B. (1983). Factor analysis and reliability studies of the Crown-Crisp Experiential Index (CCEI). *British Journal of Medical Psychology, 56,* 329–345. http://dx.doi.org/10.1111/j.2044-8341.1983.tb01565.x

Austin, S. B., Ziyadeh, N. J., Corliss, H. L., Rosario, M., Wypij, D., Haines, J., . . . Field, A. E. (2009). Sexual orientation disparities in purging and binge eating from early to late adolescence. *Journal of Adolescent Health, 45,* 238–245. http://dx.doi.org/10.1016/j.jadohealth.2009.02.001

Bailey, J. M., Vasey, P. L., Diamond, L. M., Breedlove, S. M., Vilain, E., & Epprecht, M. (2016). Sexual orientation, controversy, and science. *Psychological Science in the Public Interest, 17,* 45–101. http://dx.doi.org/10.1177/1529100616637616

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. http://dx.doi.org/10.1037/0012-1649.31.1.43

Barbaro, N., Boutwell, B. B., Barnes, J. C., & Shackelford, T. K. (2017). Genetic confounding of the relationship between father absence and age at menarche. *Evolution and Human Behavior, 38,* 357–365. http://dx.doi.org/10.1016/j.evolhumbehav.2016.11.007

Baumeister, R. F. (2000). Gender differences in erotic plasticity: The female sex drive as socially flexible and responsive. *Psychological Bulletin, 126,* 347–374. http://dx.doi.org/10.1037/0033-2909.126.3.347

Bell, A. P., Weinberg, M. S., & Hammersmith, S. K. (1981). *Sexual preference: Its development in men and women* (Vol. 2). Bloomington: Indiana University Press.

Blanchard, R. (2012). A possible second type of maternal-fetal immune interaction involved in both male and female homosexuality. *Archives of Sexual Behavior, 41,* 1507–1511. http://dx.doi.org/10.1007/s10508-011-9896-0

Blanchard, R. (2018). Fraternal birth order, family size, and male homosexuality: Meta-analysis of studies spanning 25 years. *Archives of Sexual Behavior, 47,* 1–15. http://dx.doi.org/10.1007/s10508-017-1007-4

Blanchard, R., & Bogaert, A. F. (1996). Biodemographic comparisons of homosexual and heterosexual men in the Kinsey Interview Data. *Archives of Sexual Behavior, 25,* 551–579. http://dx.doi.org/10.1007/BF02437839

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.