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Original Article

Scarcity of female mates predicts regional variation in men's and women's sociosexual orientation across US states ☆

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ABSTRACT

Previous studies have linked regional variation in willingness to engage in uncommitted sexual relationships (i.e., sociosexual orientation) to many different socio-ecological measures, such as adult sex ratio, life expectancy, and gross domestic product. However, these studies share a number of potentially serious limitations, including reliance on a single dataset of responses aggregated by country and a failure to properly consider intercorrelations among different socio-ecological measures. We address these limitations by (1) collecting a new dataset of 4,453 American men's and women's sociosexual orientation scores, (2) using multilevel analyses to avoid aggregation, and (3) deriving orthogonal factors reflecting US state-level differences in the scarcity of female mates, environmental demands, and wealth. Analyses showed that the scarcity of female mates factor, but not the environmental demand or wealth factors, predicted men's and women's sociosexual orientation. Participants reported being less willing to engage in uncommitted sexual relationships when female mates were scarce. These results highlight the importance of scarcity of female mates for regional differences in men's and women's mating strategies. They also suggest that effects of wealth-related measures and environmental demands reported in previous research may be artifacts of intercorrelations among socio-ecological measures or, alternatively, do not necessarily generalize well to new datasets.

1. Introduction

Some previous research suggests that environmental demands may be important for regional variation in individual mating strategies, such as willingness to engage in uncommitted sexual relationships (i.e., sociosexual orientation, Simpson & Gangestad, 1991). For example, people in countries with higher parasite stress (Barber, 2008; Schaller & Murray, 2008; Thornhill, Fincher, Murray, & Schaller, 2010) or with higher incidence of low birth weight and child malnutrition, higher infant mortality rates, and shorter life expectancy (Schmitt, 2005) report being less willing to engage in uncommitted sexual relationships.

These links between sociosexual orientation and environmental demands could occur because engaging in uncommitted sexual relationships increases exposure to infectious diseases and such behaviors will be more costly in more demanding environments (Schaller & Murray, 2008). Alternatively, they may occur because committed relationships reduce the negative consequences of demanding environments on offspring viability by increasing the amount of parental investment available, meaning that preferences for committed relationships are likely to be higher in regions with greater environmental demands (Schmitt, 2005). That these links between environmental demands and sociosexual orientation tend to be stronger among women than men (Schaller & Murray, 2008; Schmitt, 2005; Thornhill et al., 2010, but see Barber, 2008) may reflect that the fitness costs incurred in demanding environments, such as increased risk of contracting infectious diseases, are greater for women than for men and that the fitness benefits of engaging in uncommitted sexual relationships are greater for men than for women (Schaller & Murray, 2008; Thornhill et al., 2010).

In addition to links between environmental demands and sociosexual orientation, several lines of evidence suggest that the scarcity of female mates in the local population may be an important factor. For example, in countries with a higher ratio of men to women, higher fertility and teen pregnancy rates, or lower mean age at marriage for women, people report being less willing to engage in uncommitted sexual relationships (Schmitt, 2005, see also Barber, 2008). Men's sociosexual orientation tends to be less restricted than women's (Penke & Asendorpf, 2008; Simpson & Gangestad, 1991). Consequently, scarcity of female mates in the local population may predict *women's* sociosexual orientation because women are better able to pursue their preferred mating strategy when intrasexual competition for mates among women is less intense and they can be more selective in their mate choices (Schmitt, 2005). Scarcity of female mates in the local population may predict *men's* sociosexual orientation because men are more likely

☆ Data accessibility: Data and analysis scripts are included as electronic supplementary materials. State-level variables can be accessed from the Measure of America (http://www.measureofamerica.org/measure_of_america2013-2014/) and the American Community Survey (http://factfinder2.census.gov/).

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to align their mating strategy with those that are preferred by women when intrasexual competition for mates among men is more intense and men may need to be willing to alter their preferred mating strategy in order to obtain mates (Schmitt, 2005). Consistent with this interpretation, women do show greater selectivity in their mate preferences (Pollet & Nettle, 2008; Watkins, Jones, Little, DeBruine, & Feinberg, 2012) and men are more willing to commit to and invest in monogamous relationships (Pedersen, 1991; Pollet & Nettle, 2009) when women are relatively scarce. Recent research also demonstrates that, across bird species, pair bonds are more stable when sex ratios are male-biased (Liker, Freckleton, & Székely, 2014).

In addition to scarcity of female mates and aspects of environmental demand, such as parasite stress and other health risks, people report being more willing to engage in uncommitted sexual relationships in wealthier countries (Schmitt, 2005). This effect of wealth may occur because individuals in wealthier countries tend to have more resources to invest in their offspring and, consequently, biparental care is less important for offspring viability (Schmitt, 2005). In one study, wealth was related to women's, but not men's, sociosexual orientation (Barber, 2008), potentially reflecting women's greater engagement with offspring care.

Although the studies described above suggest that socio-ecological factors predict regional differences in sociosexual orientation (Barber, 2008; Schaller & Murray, 2008; Schmitt, 2005; Thornhill et al., 2010), they have a number of potentially important limitations.

First, the studies all analyzed scores on Simpson and Gangestad's (1991) Sociosexual Orientation Inventory (SOI) that were taken from the same dataset, which was collected by Schmitt (2005). Consequently, it is important to establish which of these results generalize to other, independent datasets.

Second, because they rely on a single dataset using Simpson and Gangestad's (1991) SOI, all of the studies analyzed global sociosexual orientation only. More recently, Penke and Asendorpf (2008) have argued that sociosexual orientation consists of three components (attitudes, desires, and behaviors) and developed a revised Sociosexual Orientation Inventory (SOI-R) to measure each of these components, in addition to a global measure of sociosexual orientation. Socio-ecological factors need not necessarily have identical effects on the three different components. For example, because attitudes and desires are not constrained in the same way that behaviors are (Penke & Asendorpf, 2008), links between socio-ecological conditions and sociosexual orientation may be more apparent when measured via attitudes and desires than when measured via behaviors.

Third, the studies all correlated measures of socio-ecological conditions with aggregated SOI scores for each country. This approach has recently been criticized because aggregating data in this way may give a misleading impression of responses typical of individuals in each region (Pollet, Tybur, Frankenhuis, & Rickard, 2014). This concern can be addressed through the use of multilevel analyses, in which individual participants' data are grouped, but not aggregated, by region (Pollet et al., 2014). Multilevel analyses also account for differences in the number of samples in each region and the variance of scores in each region. These problems arising from the analysis of aggregated data also extend to prior research linking regional differences in sex ratio to other aspects of mating strategy, such as choosiness in mate preferences (Stone, Shackelford, & Buss, 2007), access to financial resources (Griskevicius et al., 2012), and various marriage statistics (Kruger, 2009; Lichter, McLaughlin, Kephart, & Landry, 1992; South & Trent, 1988).

Fourth, although measures of the scarcity of female mates, environmental demands, and wealth are often intercorrelated (Barber, 2008; Schmitt, 2005), the studies have not always controlled for the possible effects of these intercorrelations. For example, Schmitt (2005) presents only simple correlations between socio-ecological factors and sociosexual orientation, while Thornhill et al. (2010) only considered the possible effects of parasite stress. Schaller and Murray (2008) demonstrate that the effect of disease prevalence on women's sociosexual orientation was not due to the possible effects of wealth and life expectancy, but did not consider the possible effects of measures of the scarcity of female mates. Barber (2008) tested for independent effects of several aspects of environmental demand, scarcity of female mates, and wealth, reporting evidence that some of these measures have independent effects. However, these analyses also suggested that controlling for multiple, correlated socio-ecological factors can dramatically alter the nature of their effects. For example, the effect of infectious disease on women's sociosexual orientation was significant and negative in a simple correlation analysis, but significant and positive when effects of other measures were controlled (Barber, 2008). Consequently, it is unclear whether scarcity of female mates, environmental demands, and wealth do have independent effects on regional variation in sociosexual orientation.

To address the problems described above, we tested for possible relationships between sociosexual orientation and regional variation in scarcity of female mates, environmental demands, and wealth in a new dataset of men and women from 50 U.S. states (and Washington DC). First, we used principle component analysis to investigate the factor structure of measures of state-level variation in scarcity of female mates (i.e., adult sex ratio, fertility rate, teenage pregnancy rate, women's age at first marriage), environmental demands (i.e., infant mortality, low birth weight, life expectancy at birth, children living in poverty), and wealth (gross domestic product per capita, Human Development Index). These specific variables were selected because they are the closest US state-level analogues to the measures of country-level variation that were analyzed by Schmitt (2005). This initial analysis produced a three-factor solution in which the factors primarily reflected state-level variation in scarcity of female mates, environmental demands, and wealth (see Table 1). We then used multilevel analyses to test for independent relationships between these factors and participants' scores on Penke and Asendorpf's (2008) revised Sociosexual Orientation Inventory (SOI-R). Each of the three different components of sociosexual orientation (attitudes, desires, and behaviors) was analyzed, in addition to the global measure.

2. Methods

2.1. Participants

A total of 3209 heterosexual women (mean age = 23.4 years, SD = 5.94 years) and 1244 heterosexual men (mean age = 25.9 years, SD = 7.59 years) participated in the online study (total N = 4453). Online data collection has been used in many previous studies of sociosexual orientation (Penke & Asendorpf, 2008) and regional differences in both mate preferences (DeBruine, Jones, Crawford, Welling, & Little, 2010; DeBruine, Jones, Crawford, & Welling, 2011) and mating-related attitudes (e.g., Price, Pound, & Scott, 2014). Participants were recruited by following links from social bookmarking websites (e.g., stumbleupon.com) and were not compensated for their participation.

Table 1
Component matrix for principle component analysis of all state-level variables.

State-level variables	Environmental demand factor	Scarcity of female mates (SoFM) factor	Wealth factor
Infant mortality rate	.853	−.175	−.007
% of low-birth-weight infants	.846	−.245	.167
Teenage pregnancy rate	.867	.371	−.003
Life expectancy at birth	−.935	−.043	.075
% of children living in poverty	.866	−.045	−.275
Adult sex ratio	−.342	.791	−.204
Fertility rate	.083	.901	.082
Women's median age at first marriage	−.140	−.822	.415
Gross domestic product per capita	−.030	−.147	.943
Human development index	−.735	−.347	.541

2.2. Revised Sociosexual Orientation Inventory (SOI-R)

All participants completed the SOI-R, a questionnaire that measures individual differences in willingness to engage in uncommitted sexual relationships and has good test-retest reliability and good external validity (Penke & Asendorpf, 2008). Items on the SOI-R are drawn from three subscales indexing individual differences in behavior (e.g., "With how many different partners have you had sexual intercourse on one and only one occasion?"), attitudes (e.g., "Sex without love is OK."), or desires (e.g., "In everyday life, how often do you have spontaneous fantasies about having sex with someone you have just met?"). Scores on these subscales can also be summed to create a global measure of sociosexual orientation (Penke & Asendorpf, 2008). Higher scores on each of the subscales or the global measure indicate greater willingness to engage in uncommitted sexual relationships. We used the five-point response scale version of the SOI-R (Penke & Asendorpf, 2008).

2.3. State-level variables

For each state plus Washington DC, data for the human development index, gross domestic product per capita, infant mortality rate (per 1000 live births), percent of low-birth-weight infants (percent of all infants with birth weights below 2500 g), teenage pregnancy rate (number of births per 1000 girls aged 15–19 years), life expectancy at birth, and percent of children (under 6 years of age) living in poverty were obtained from the US Social Science Research Council (The Measure of America, 2013–2014). Data provided in this report are for 2010. Data for women's median age at first marriage, fertility rate (number of women with births in the previous 12 months per 1000 women), and adult sex ratio (total number of men aged between 15 and 49 years of age divided by the total number of women aged between 15 and 49 years of age) were obtained from the 2010 US Census Bureau (American Community Survey, 2010).

3. Results

First, we subjected all state-level variables to Principal Component Analysis (PCA) using varimax rotation and Kaiser normalization. This analysis produced 3 orthogonal factors (see Table 1). The first factor explained 45.0% of the variance in scores and was highly correlated with life expectancy at birth and infant mortality rate. We labeled this factor the *environmental demand factor*. The second factor explained 24.9% of the variance in scores and was highly correlated with fertility rate, adult sex ratio, and women's median age at first marriage. We labeled this factor the *scarcity of female mates* (*SoFM*) *factor*. The third factor explained 15.1% of the variance in scores and was highly correlated with gross domestic product per capita. We labeled this factor the *wealth factor*. Repeating this factor analysis using direct oblimin rotation produced three non-orthogonal factors, each of which was highly correlated with the corresponding factor produced using varimax rotation (all $|r| > .98$). This suggests that the results of our multilevel analyses using these factors are not an artifact of the factors being forced to be orthogonal.

We first tested for between-state effects of the *environmental demand factor*, *scarcity of female mates* (*SoFM*) *factor*, and *wealth factor* on participants' global SOI-R scores (i.e., the sum of scores on the three SOI-R subscales) using multilevel modeling. All analyses were carried out using R (R Core Team, 2013), *lme4* (Bates, Maechler, Bolker, & Walker, 2014), and *lmerTest* (Kuznetsova, Brockhoff, & Christensen, 2013) packages. The full output for each model is included in our supplemental materials (Appendix B).

Participants were grouped by state (each participant's Internet Protocol address was used to determine their location) and global SOI-R scores were entered as the dependent variable at the participant level. *Participant age* (centered at the mean age) and *participant sex* (dummy coded as 0 = female, 1 = male) were entered as predictors at the participant level and scores on the *environmental demand factor*, *SoFM factor*, and *wealth factor* were entered at the state level. The model included a random intercept term at the state level. Initial analyses with interactions between participant sex and the *environmental demand factor*, *SoFM factor*, and *wealth factor* at the participant level revealed no significant interactions (*participant sex * environmental demand*: $t = 1.24$, $p = .215$; *participant sex * SoFM*: $t = 0.59$, $p = .557$; *participant sex * wealth*: $t = 1.02$, $p = .308$). Consequently, these interactions were dropped from the model, in order to interpret the overall effects of the three socio-ecological factors.

This analysis revealed a significant negative effect of the *SoFM factor* ($t = -4.02$, $p < .001$), indicating that participants in states where female mates were more scarce reported being less willing to engage in uncommitted sexual relationships. In contrast, the *environmental demand factor* ($t = -1.27$, $p = .211$) and *wealth factor* ($t = 1.20$, $p = .234$) did not have significant effects. A significant effect of *participant sex* ($t = 15.6$, $p < .001$) indicated that men generally reported being more willing to engage in uncommitted sexual relationships than did women. A significant effect of *participant age* ($t = 9.35$, $p < .001$) indicated that older participants generally reported being more willing to engage in uncommitted sexual relationships than did younger participants.

Next, we repeated this analysis separately for scores on each of the three subscales of the SOI-R. We carried out these analyses in light of preliminary analyses that indicated differences in the relationships between the *SoFM factor* and scores on the three SOI-R subscales.

Analysis of the attitude subscale revealed no interactions between *participant sex* and any of the state-level factors (*participant sex * environmental demand*: $t = 0.49$, $p = .623$; *participant sex * SoFM*: $t = -0.06$, $p = .950$; *participant sex * wealth*: $t = 1.06$, $p = .289$), so these interactions were dropped from the model. This analysis showed a significant negative effect of the *SoFM factor* ($t = -4.42$, $p < .001$) and effects of both *participant sex* ($t = 14.17$, $p < .001$) and *participant age* ($t = 7.19$, $p < .001$). Men had higher scores on the attitude subscale than did women and older participants had higher scores on the attitude subscale than did younger participants. There were no effects of the *environmental demand factor* ($t = -1.53$, $p = .134$) or the *wealth factor* ($t = 0.93$, $p = .354$).

Analysis of the desire subscale revealed no interactions between *participant sex* and the *SoFM factor* ($t = 0.01$, $p = .990$) or *participant sex* and the *wealth factor* ($t = 0.67$, $p = .506$), so these interactions were dropped from the model. Here, the analysis revealed a significant negative effect of the *SoFM factor* ($t = -3.24$, $p = .002$), a significant effect of *participant sex* ($t = 25.1$, $p < .001$), and a significant negative effect of *participant age* ($t = -2.41$, $p = .016$). Men had higher scores on the desire subscale than did women and older participants had lower scores on the desire subscale than did younger participants. Additionally, this analysis of the desire subscale of the SOI-R showed a significant positive effect of the *wealth factor* ($t = 2.10$, $p = .040$) and a negative effect of the *environmental demand factor* ($t = -2.14$, $p = .035$), which was qualified by an interaction between *environmental demand* and *participant sex* ($t = 2.14$, $p = .033$). This interaction indicated that women, but not men, in states with more demanding environments reported lower scores on the desire subscale of the SOI-R.

Analysis of the behavior subscale revealed no interactions between *participant sex* and any of the state-level factors (*participant sex * environmental demand*: $t = 0.25$, $p = .801$; *participant sex * SoFM*: $z = 1.58$, $p = .115$; *participant sex * wealth*: $t = 0.64$, $p = .524$), so these interactions were dropped from the model. This analysis showed significant effects of *participant sex* ($t = -3.71$, $p < .001$) and *participant age* ($t = 18.0$, $p < .001$). Women had higher scores on the behavior subscale than did men and older participants had higher scores on the behavior subscale than did younger participants. There were no other effects of state-level variables (*environmental demand*: $t = 0.12$, $p = .908$; *SoFM*: $t = -1.31$, $p = .196$; *wealth*: $t = -0.11$, $p = .910$).

3.1. Additional analyses

Although our main analyses used a composite measure of environmental demand that was based on the measures used in Schmitt's (2005) analyses of regional variation in sociosexual orientation, other studies have used measures of parasite stress (i.e., measures of the incidence of infectious diseases, specifically) to investigate this issue (Fincher & Thornhill, 2012). Because parasite stress and our *environmental demand factor* could plausibly tap different aspects of environmental demand, we repeated our analyses replacing our *environmental demand factor* with Fincher and Thornhill's (2012) measure of US state-level variation in *parasite stress*. Fincher and Thornhill's (2012) measure of *parasite stress* was derived from US Center for Disease Control (CDC) statistics for the incidence of infectious diseases between 1993 and 2007. The results of these alternative analyses of our data are summarized below and are described in full in our supplementary materials (Appendix C).

For the analyses of global SOI-R and the attitude subscale, the negative effects of *SoFM* remained significant and neither *wealth* nor *parasite stress* had any significant effects. For the analysis of the desire subscale, the negative effect of *SoFM* and positive effect of *wealth* remained significant and there were no significant effects of *parasite stress*. For the analysis of the behavior subscale, *SoFM*, *wealth*, and *parasite stress* did not have any significant effects. These alternative analyses suggest that the absence of consistent effects of our environmental demand factor in our main analyses is not a consequence of this factor inadequately reflecting state-level variation in parasite stress.

4. Discussion

We tested for possible relationships between participants' sociosexual orientation and US state-level variation in socio-ecological variables previously found to predict country-level variation in sociosexual orientation (e.g., Schmitt, 2005). Principle component analysis of these socio-ecological variables produced three orthogonal factors reflecting state-level variation in scarcity of female mates, environmental demands, and wealth. Multilevel analyses showed that the scarcity of female mates factor, but not environmental demand or wealth factors, predicted variation in men's and women's global sociosexual orientation. Participants in states where female mates were particularly scarce reported being less willing to engage in uncommitted sexual relationships.

Our findings complement Schmitt (2005), who also suggested that measures of the scarcity of female mates in the local population were a particularly important socio-ecological factor for regional differences in sociosexual orientation. Importantly, we extend this previous work in several ways.

First, all previous research on this issue used the same dataset, which was collected by Schmitt (2005). We show that the conclusion that scarcity of female mates is a particularly important socio-ecological factor for regional differences in sociosexual orientation is also true of a new dataset. In addition, this new dataset was collected from participants in a single country, addressing concerns that translating Simpson and Gangestad's (1991) Sociosexual Orientation Inventory (SOI) into multiple languages may introduce systematic country-level differences in SOI scores (Schmitt, 2005).

Second, while previous work examined a global measure of sociosexual orientation only, our use of Penke and Asendorpf's (2008) Revised Sociosexual Orientation Inventory (SOI-R) meant that we could investigate regional variation in the different components of sociosexual orientation (attitude, desire, and behavior), in addition to global sociosexual orientation. Our analyses of these different subscales showed that scarcity of female mates predicted scores on the attitude and desire subscales, but not the behavior subscale. Because attitudes and desires are not constrained in the same way that behaviors are (Penke & Asendorpf, 2008), this pattern of results supports the proposal that regional differences in sociosexual orientation reflect psychological adaptations evoked by the local environmental conditions (Schaller & Murray, 2008; Schmitt, 2005; Thornhill et al., 2010). Additionally, while the environmental demand and wealth factors were not implicated in global SOI-R scores, analyses of individual subscales of the SOI-R showed that the desire subscale was also related to the environmental demand factor in female participants and wealth factor in both sexes. These latter results suggest that some aspects of sociosexual orientation may be influenced by environmental demands and wealth, independent of the effects of scarcity of female mates.

Third, we investigated the relationships between socio-ecological measures and sociosexual orientation using a method in which individual participants' data are grouped, but not aggregated, by region. This is important because aggregating data may give a misleading impression of the responses that are typical for individuals in each region (Pollet et al., 2014). Our analyses address this concern using multilevel analyses, following recent recommendations by Pollet et al. (2014).

Fourth, prior work either used simple correlations to demonstrate relationships or used multiple regression to simultaneously test for the possible effects of many intercorrelated variables. By contrast, we used factor analysis to generate three orthogonal factors, each reflecting a different aspect of socio-ecological condition: scarcity of female mates, environmental demands, and wealth. We then showed that state-level variation in global sociosexual orientation was predicted by the scarcity of female mates factor, but not the environmental demand or wealth factors. Similar results were obtained when we replaced our environmental demand factor with Fincher and Thornhill's (2012) parasite stress measure, suggesting that our largely null results for the environmental demand factor were not a consequence of this factor inadequately reflecting variation in parasite stress. Thus, our results raise the possibility that the effects of measures of environmental demand and wealth on sociosexual orientation reported in previous research (Barber, 2008; Schaller & Murray, 2008; Schmitt, 2005; Thornhill et al., 2010) may be due to intercorrelations with measures of the scarcity of female mates or, alternatively, do not generalize to this new dataset. Perhaps more importantly, our results suggest that the effect of scarcity of female mates emphasized by Schmitt (2005) is not an artifact of effects of environmental demands or wealth, at least in our sample.

Our study addresses key limitations of prior work (Barber, 2008; Schaller & Murray, 2008; Schmitt, 2005; Thornhill et al., 2010) to present strong evidence for a link between scarcity of female mates and regional differences in men's and women's mating strategies. Interestingly, our results also complement other recent work demonstrating that, across bird species, pair bonds are more stable when sex ratios are male-biased (Liker et al., 2014). Together, these results suggest that scarcity of female mates can have similar effects on mating strategies in diverse taxa. We suggest that further work is needed to investigate the causal links among regional differences in the scarcity of female mates, individuals' sociosexual orientations, and regional differences in cultural norms and values, such as anti-promiscuity morality (Price et al., 2014).

Supplementary Materials

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.evolhumbehav.2014.11.004.

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