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Why are some people more jealous than others? Genetic and environmental factors

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ABSTRACT

Research on romantic jealousy has traditionally focused on sex differences. We investigated why individuals vary in romantic jealousy, even within the sexes, using a genetically informed design of ~7700 Finnish twins and their siblings. First, we estimated genetic, shared environmental and nonshared environmental influences on jealousy, Second, we examined relations between jealousy and several variables that have been hypothesized to relate to jealousy because they increase the risk (e.g., mate-value discrepancy) or costs (e.g., restricted sociosexuality) of infidelity. Jealousy was 29% heritable, and non-shared environmental influences explained the remaining variance. The magnitude and sources of genetic influences did not differ between the sexes. Jealousy was associated with: having a lower mate value relative to one's partner; having less trust in one's current partner; having been cheated by a previous or current partner; and having more restricted sociosexual attitude and desire. Within monozygotic twin pairs, the twin with more restricted sociosexual desire and less trust in their partner than his or her co-twin experienced significantly more jealousy, showing that these associations were not merely due to the same genes or family environment giving rise to both sociosexual desire or trust and jealousy. The association between sociosexual attitude and jealousy was predominantly explained by genetic factors (74%), whereas all other associations with jealousy were mostly influenced by nonshared environmental (non-familial) factors (estimates >71%). Overall, our findings provide some of the most robust support to date on the importance of variables predicted by mate-guarding accounts to explain why people vary in jealousy.

1. Introduction

Romantic jealousy is elicited by perceived threats to a romantic relationship, such as the perception of one's mate being romantically interested in a rival, or of a rival being romantically interested in one's mate (White, 1981). Evolutionary accounts interpret such jealousy as functioning to deter those threats by motivating mate-guarding behaviors, such as increased vigilance or partner-directed aggression. These behaviors are thought to reduce the likelihood of infidelity or mate abandonment, thereby increasing reproductive success (Buss & Shackelford, 1997; Daly, Wilson, & Weghorst, 1982; Symons, 1979). Due to the problem of paternity uncertainty, it is thought that partner sexual infidelity poses a greater risk to males' than females' fitness, whereas loss of a partner's relationship commitment and resources poses greater risk to females' than males' fitness (Trivers, 1972). In line with this idea, Buss, Larsen, Westen, and Semmelroth (1992) found male jealousy to be elicited more by the threat of a mate's sexual infidelity and female jealousy by a mate's emotional infidelity. Since this landmark study, the past three decades of research on jealousy have focused mostly on sex differences (Buss, 2018; Edlund & Sagarin, 2017). Although such research has been useful in testing the sex-differentiated nature of jealousy, it has done little to inform about the sources of individual differences in jealousy. Yet research shows that people vary considerably in their tendency to experience jealousy, even within the sexes (Pfeiffer & Wong, 1989; White, 1981). This variation has important inter-personal and social consequences, including relationship conflict

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(White, 2008), domestic violence (Burch & Gallup Jr, 2020; Buss & Duntley, 2011), homicide (Daly & Wilson, 1988), depression, suicide attempts, and relationship dissatisfaction (Carson & Cupach, 2000; Martínez-León, Peña, Salazar, García, & Sierra, 2017). Here, we: (1) examine whether variation in jealousy is the result of genetic, shared environmental or nonshared environmental factors, and (2) examine specific variables that have been hypothesized to influence jealousy.

1.1. *Genetic, shared environmental and nonshared environmental sources of variation*

Our first aim was to disentangle environmental and genetic sources of variation in romantic jealousy. To accomplish this goal, we used a classical twin study design, which assesses monozygotic and dizygotic twins to estimate the extent to which genetic effects, shared environmental effects (e.g., parenting), or nonshared environmental effects (e.g., romantic relationship experiences) underlie phenotypic variance. Understanding these contributions from these sources of variation can inform theoretical accounts of why people vary in jealousy.

According to attachment theory, mental models of relationship expectations are environmentally transmitted from parents during infancy (Bowlby, 1969; Fonagy & Target, 2005; Van IJzendoorn, 1995; Verhage et al., 2016; c.f., Barbaro, Boutwell, Barnes, & Shackelford, 2017). Adults' expectations about romantic relationships – and their responses to these expectations, such as anxiety about abandonment – are putatively built upon these models (Hazan & Shaver, 1987; Simpson, 1990), which in turn determine emotional reactions, including jealousy, towards perceived relationship threats (Guerrero, 1998; Mikulincer & Shaver, 2005; Sharpsteen & Kirkpatrick, 1997). Transmission accounts such as these predict that family members show similarities in jealousybecause they are exposed to the same models of attachment from the same parents. Further, these similarities should not be entirely accounted for by genetic similarities, that is, they should result from shared family environmental influences.

Many evolutionary accounts regard romantic jealousy as a trait separate from attachment, with its own distinct function of mate-guarding (Buss & Shackelford, 1997; Daly et al., 1982; Symons, 1979). According to these accounts, variation in jealousy is shaped by variables that either increase the benefits of mate-guarding or increase the costs of infidelity. Hence, jealousy may be calibrated to the condition of the individual (Tooby & Cosmides, 1990). For example, more attractive, healthier, or taller individuals may experience less risk of infidelity, and are therefore less prone to jealousy (Arnocky, Pearson, & Vaillancourt, 2015; Brewer & Riley, 2009; Buunk, Park, Zurriaga, Klavina, & Massar, 2008). Because variation in these traits is heritable, calibration accounts predict that variation in jealousy should also be heritable (Lewis, Al-Shawaf, Janiak, & Akunebu, 2018). Socio-ecological factors can also influence the benefits of mate-guarding. For example, the availability of alternative mates, the attractiveness of one's current mate, and the number and quality of rivals, can alter the costs or risks of infidelity, and therefore influence jealousy, which functions to mitigate these risks (Arnocky, Ribout, Mirza, & Knack, 2014; Buss, 2013; Dijkstra and Buunk, 1998). Because these socio-ecological factors can vary independently of genes or family environment, mate-guarding accounts predict that the nonshared environment should be a source of variation in jealousy.

1.2. *Specific sources of variation*

Our second aim was to assess the influence of several of the variables that have been predicted by mate-guarding accounts to influence variation in jealousy. These factors include *mate-value discrepancy* (i.e., the individual's mate value compared to their partner's mate value), the partner's *trustworthiness*, and the individual's *sociosexual orientation* (Buss, 2013).

1.2.1. *Mate value discrepancy*

Having a partner with higher mate value than one's own can increase the threat of infidelity because the partner elicits more interest from rivals and may themselves be more able to upgrade to a higher value mate (Buss, 2013; Wilson & Daly, 1996). Findings suggest that higher mate value discrepancy is associated with higher jealousy (Sidelinger & Booth-Butterfield, 2007) and with more frequent mate-guarding behaviors motivated by jealousy (Buss & Shackelford, 1997).

1.2.2. *Mate trustworthiness*

Jealousy increases when a partner's behavior indicates an increased likelihood of infidelity, such as when they dance or flirt with another person (Dijkstra, Barelds, & Groothof, 2010; Schützwohl, 2005). Accordingly, past experiences of infidelity are related to increased jealousy, especially among men (Bendixen et al., 2015; Burchell & Ward, 2011; Edlund, Heider, Scherer, Farc, & Sagarin, 2006; Murphy, Vallacher, Shackelford, Bjorklund, & Yunger, 2006; Sagarin, Becker, Guadagno, Nicastle, & Millevoi, 2003). Conversely, feeling that a partner is trustworthy is negatively associated with jealousy (Kemer, Bulgan, & Yıldız, 2016).

1.2.3. *Sociosexual orientation*

People vary in the extent to which they prioritize forming exclusive romantic relationships (i.e., relatively monogamous, or *restricted sociosexuality*) versus short-term casual sexual relationships (i.e., relatively promiscuous or *unrestricted sociosexuality*) (Buss & Schmitt, 1993; Gangestad & Simpson, 2000). Individuals who pursue more exclusive relationships have more to lose from threats of cuckoldry or mate poaching, as their fitness is more dependent on reproducing with one mate. Those with a more restricted sociosexual orientation may therefore experience higher jealousy (Brase, Adair, & Monk, 2014), though several studies have not detected this association (Harris, 2003; Peters, Eisenlohr-Moul, Pond Jr, & DeWall, 2014; Russell & Harton, 2005).

We aimed to more precisely estimate these associations by using a much larger sample size (> 7000) than used in previous studies such as those cited above. Our genetically-sensitive sample also allowed us to examine the nature of these associations in a novel manner. Specifically, we tested whether associations between jealousy and the variables described above arise because of genetic, shared or nonshared environmental factors. Further, we evaluated whether these associations remained after controlling for shared genetic and shared environmental effects (e.g., if the same familial factors give rise to both jealousy and trust in one's partner).

1.3. *Current research*

The classical twin design can be used to partition phenotypic (i.e., observed) variation into genetic, shared environmental, and nonshared environmental components because monozygotic (MZ) twins share nearly all of their genes (~100%), whereas dizygotic (DZ) twins and siblings share, on average, 50% of their segregating genes. Both MZ and DZ twins share the same family environment (e.g., the same parents). Hence, if only genetic factors caused twins to be similar to each other, then MZ twin correlations would be (at least) double DZ twin correlations. In contrast, if only shared environmental influences (e.g., parenting) caused twins to be similar to each other, then MZ twin correlations and DZ twin correlations would be equal. MZ twin correlations more than double the size of DZ twin correlations suggest the presence of non-additive genetic influences. Any dissimilarity (a departure from $r = 1$) between MZ twins is attributable to nonshared environmental influences and measurement error. Here, we used a sample of ~7700 Finnish twins and their siblings to first estimate the magnitude of genetic, shared environmental and nonshared environmental influences on jealousy. We then examined the effect of the aforementioned three factors that have been proposed to influence variation in jealousy: (1) mate value discrepancy; (2) cues to a mate's likelihood of infidelity (namely trust and actual experiences of infidelity); and (3) sociosexuality. By extending the classical twin design to two variables (*bivariate model*) we estimated the degree to which the associations between jealousy and the putative predictors of jealousy can be accounted for by overlapping genetic, shared environmental, and nonshared environmental factors. These bivariate variance component estimates do not typically provide causal information, because different causal possibilities can yield similar variance component estimates. For indications about the likelihood of different causal possibilities we also used co-twin control design (McGue, Osler, & Christensen, 2010), in which MZ co-twins are used to control for familial (including genetic) confounding of the associations between variables.

2. Methods

2.1. Participants

Twins and their siblings were recruited from the Central Population Registry in Finland. As part of a larger study, 7726 individuals (5660 twins and 2062 siblings, 4 unknown) completed items concerning jealousy and gave consent for the use of their data for scientific purposes. No data on jealousy was collected from participants who reported being homosexual. Of the participants, 5188 completed questions on mate value discrepancy, 5016 on pair-bonding (i.e., trust in relationship), 7726 on experiencing infidelity in the past and 7708 on sociosexual orientation. Of the 7726 total individuals, 5197 were in a romantic relationship, of which 4906 described their relationship as monogamous. Of those 4906 individuals, 471 reported having cheated on a partner, 187 reported having been cheated on by a partner, and 160 reported having both cheated on a partner and having been cheated upon. The full sample was used to test associations between individual's level of jealousy and the predictors. The individual data came from twins and siblings from 4499 families, including data from 3342 twin singletons, 1157 complete twin pairs (112 monozygotic male (MZm), 343 monozygotic female (MZf), 106 dizygotic male (DZm), 301 dizygotic female (DZf), and 295 dizygotic opposite-sex (DOS) twin pairs), and 773 siblings of a twin (540 female, 234 male). These were the data used for the genetic analyses (further information on the sample sizes is provided in Table 1). Twins were aged between 18 and 45 years ($M = 29.28$, $SD = 7.75$), and siblings between 18 and 58 ($M = 32.2$, $SD = 8.50$). A more detailed description of the data collection and information on zygosity estimation is provided by Tybur, Wesseldijk, and Jern (2020).

2.2. Measures

2.2.1. Romantic jealousy

Eleven items describing a variety of jealousy-evoking situations were written for the present study (see Appendix). Participants reported their level of discomfort with their partner engaging in behaviors with another person, such as 'touching while talking,' and 'kissing on the lips'. Answers were given on a 7-point scale, with 1 = 'Extremely comfortable', 4 = 'Neutral' and 7 = 'Extremely uncomfortable'. To examine the dimensionality of these items, we conducted an exploratory factor analysis on the eleven jealousy items using maximum likelihood extraction in SPSS. The scree plot indicated a one- or two-factor structure, with a large drop from the first eigenvalue to the second and much smaller drops thereafter (the five highest eigenvalues were 6.26, 1.63, 0.75, 0.60, 0.39). After rotating (via direct oblimin) the two extracted factors, those items with the highest loadings on the second factor were not conceptually distinct from those loading on the first factor. We therefore treated the items as unidimensional (α = 0.92).

2.2.2. Mate value discrepancy

Similar to several previous studies (e.g., Brase & Guy, 2004) wholistic measures of mate-value were used. All participants answered the question 'Overall, how would you rate your level of desirability as a partner on the following scale compared to others of same sex?' on a 9-point scale, with 1 = 'Extremely undesirable' and 9 = 'Extremely desirable'. Participants currently in a relationship also answered the question 'If you have a partner, overall, how would you rate your partner's level of desirability as a partner on the following scale, compared to others of same sex?' on the same 9-point-scale. We subtracted the participant's desirability from partner desirability. For ease of interpretation, we added eight to the difference between partner- and self-rated desirability to have values of zero or above, with higher scores indicating perceptions of lower mate value relative to one's partner. The final score ranged from 0 to 16 with a mean of 8.79 ($SD = 1.71$).

Table 1
Sample sizes for the genetic analyses, romantic jealousy within twin pair correlations (95% CIs) per zygosity-by-sex group, correlation estimates constrained to be the same across sex (for MZ and DZ pairs), sibling with twin member correlations, and correlation estimates constrained to be the same across siblings and MZ/DZ and sibling.

	N		Correlation
	Complete pairs	Incomplete pairs	
MZm	112	287	0.25 (0.08;0.40)
DZm	106	487	0.00 (−0.18;0.19)
MZf	343	499	0.31 (0.21;0.41)
DZf	302	735	0.16 (0.04;0.26)
DOS	295	1334	0.10 (−0.01;0.20)
MZ			0.30 (0.21;0.37)
DZ			0.11 (0.03;0.18)
Siblings			
Brothers		234	
With male twin			0.00 (−0.18;0.19)
With female twin			0.02 (−0.12;0.12)
Sisters		540	
With male twin			0.14 (0.03;0.24)
With female twin			0.04 (−0.08;0.15)
Total same-sex sibling			0.03 (−0.10;0.13)
Total opposite-sex sibling			0.06 (0.00;0.13)
Total siblings			0.06 (0.00;0.13)
Total MZ/DZ + sibling			0.08 (0.03;0.13)

2.2.3. Partner's trustworthiness

Participants currently in a relationship answered the question 'How much do you trust your partner?' on a 7-point scale, with 1 = 'Not at all' and 7 = 'Very much'.

2.2.4. Sociosexual orientation

All participants completed the revised Sociosexual Orientation Inventory (SOI-R, Penke & Asendorpf, 2008). This 9-item instrument includes subscales for sociosexual attitude (e.g., 'Sex without love is OK'), behavior (e.g., 'With how many different partners have you had sexual intercourse without having an interest in a long-term committed relationship with this person?'), and desire (e.g., 'In everyday life, how often do you have spontaneous fantasies about having sex with someone you have just met?'). All questions were answered on a 9-point scale with '1' indicating disagreement or low values and '9' indicating agreement or high values. As we were interested in the individual's strategies and ideas about relationships, which are not necessarily reflected in behavior, we analyzed only the attitude and desire subscales.

2.2.5. Cheating

All participants answered the question 'How many times have you been cheated on in a committed, exclusive relationship?' In total, 2279

(33.20%) of the 5447 participants reported having been cheated on one or more times. As responses ranged from 0 to 1000 ($SD = 12.32$), we decided to winsorize at the 99th percentile, resulting in a range from 0 to 8 with a mean of 0.67 ($SD = 1.33$). Individuals currently in a relationship were also asked 'Have either of you cheated during your relationship?' and specified whether they, their partner, both them and their partner, or neither (or unknown) had cheated in their relationship. We used these answers to create a variable indicating whether the partner had cheated or not. If both the individual and their partner had cheated, the variable was treated as missing. The variable was also treated as missing if the participant reported having a non-monogamous relationship.

2.3. Statistical analyses

We used multiple statistical approaches to address our research questions. As is standard in twin research, we used structural equation modeling to estimate (sex-specific) environmental and genetic sources of variation in romantic jealousy (a univariate model). We also performed regression analyses to assess relations between jealousy and variables predicted by mate-guarding accounts of jealousy. To estimate the extent to which genetic and environmental factors underlie association between each predictor and romantic jealousy we used structural equation models (bivariate models). Finally, to test whether the association could be causal in nature, we used discordant twin designs.

We performed structural equation modeling in OpenMx in R (Boker et al., 2011). We first fitted a saturated model, which includes all possible parameter estimates. Such a saturated model estimates different means and standard deviations for male and female MZ twins, DZ twins, and siblings and different correlations between MZ twins, DZ twins, and siblings. We then iteratively constrained these parameters to be equal (e.g., estimating a model in which means for men are equal to means for women) and compared the fit of such models with that of the less-constrained models (e.g., that in which means are estimated separately for both sexes). Significance testing was done using χ^2 tests ($\alpha < 0.05$) using the difference between the negative log-likelihoods (−2LLs) and the difference in degrees of freedom of the two models. If the equality constraints did not significantly diminish model fit, the more parsimonious model was chosen. Such comparisons of model fit allow for inferences of, for example, sex differences in mean jealousy (if a model that estimates the sexes to have the same mean fits worse than a model in which the means are estimated separately), or the presence of shared environmental factors (if a model that constrains the variance component estimate of the shared environmental to be zero fits worse than a model where this estimate is estimated freely). Posthuma et al. (2003) offer an accessible primer on this approach.

We tested for differences between the means of monozygotic and dizygotic twins, of twins and siblings, and of men and women (models 2, 4 and 6, Table S1). To check for the presence of twin contrast effects (whereby the behavior of one MZ twin affects the behavior of their co-twin more so than for DZ twin pairs or siblings; Carey, 1986), we constrained the standard deviations to be equal across MZ and DZ twin pairs, and across MZ/DZ twin and sibling pairs (models 3 and 5, Table S1). We also assessed twin-specific environmental influences (whereby DZ twins are more similar to each other than siblings are, despite having the same genetic similarity) by constraining the correlation of a MZ or DZ twin member with their non-twin sibling to be equal to the correlation of DZ male, female, and opposite-sex pairs (model 8, Table S1). Next, we estimated sex differences in the contribution of genetic and environmental influences on jealousy (i.e., quantitative sex differences) by testing whether the correlation between same-sex MZ and DZ/sibling pairs were similar for men and women (model 9, Table S1). Lastly, we estimated sex differences in the sources of genetic and environmental influences on jealousy (i.e., qualitative sex differences) by testing whether the DZ/sibling pair correlation could be constrained to be equal to the DOS twin pair or opposite-sex sibling pair correlation (model 10 in Table S1).

We then proceeded with a *univariate genetic structural equation model*, in which variation in jealousy is partitioned into additive genetic (A), dominant non-additive genetic effects (D), family common environmental (C), and non-shared environmental (E) components. Because C and D have opposing effects on the DZ correlations, they cannot be estimated simultaneously in the classical twin design. Significance testing of C and D was done using the χ^2 test as explained above, where the constraint here is forcing C or D to be equal to zero.

Next, we performed six separate *regression analyses* to test whether levels of jealousy were related to the predictors ($\alpha < 0.05$), while controlling for age. We report the main effect of the predictor on jealousy while including interactions with sex (centered) and the predictor, and with relationship status (centered) and the predictor. To estimate simple effects of the predictor in case of significant interactions, we performed additional regression analyses setting the reference group to zero for individuals in a relationship, individuals not in a relationship, males or females. For ease of interpretation of the regression coefficients, we standardized all measures. To correct for relatedness of the twins, we used the robust standard error estimator for clustered observations in STATA.

In a similar way to the univariate genetic structural equation model, on the basis of cross-twin-cross-trait correlations, we estimated A, C or D and E influences on the covariance between jealousy and each predictor of interest. After a visual inspection of the cross-trait-cross-twin correlations (see Table S2; see Table S3 for testing for sex differences in the predictors), we fitted six *bivariate genetic structural equation models* to estimate A and E influences on the covariance between jealousy and 1) sociosexual attitude, 2) sociosexual desire, 3) mate value discrepancy, 4) trust in partner, 5) number of times participants had been cheated on, and 6) whether the participant had been cheated on by his or her current partner.

Discordant-twin design analyses were then conducted using MZ twins to test whether associations are in line with a causal hypothesis, namely whether associations remain when controlling for shared genetic and shared environmental factors. If, for example, higher mate value discrepancy causes higher jealousy, we would expect the MZ twin that experiences higher mate value discrepancy than his or her co-twin to score higher on jealousy. Within-pair linear regression analyses were conducted per predictor using the *xtreg fe* statement in STATA, which allows for stratification by twin pair. Only complete MZ twin pairs discordant on the independent variable of interest contribute to these within-pair analyses. This is why the sample size is smaller, and also varies depending on how many MZ twin pairs differed in their score for each independent variable. Correcting for sex and age is not necessary, as each MZ twin is matched to his or her co-twin, who shares the same sex and age.

All data and materials are publicly available via OSF and can be accessed at https://bit.ly/3xrBrjm.

3. Results

3.1. Preliminary analyses: Are there sex and twin-specific influences on variation in jealousy?

Mean scores for jealousy were higher for women than for men ($p < .001$, $d = 0.46$; see Table 2 for the mean scores; model 6 in Table S1). We did not detect sex differences in the magnitude of genetic and environmental influences (i.e., same-sex male and same-sex female sibling-twin pair correlations could be constrained to be equal, $p = .36$; model 9 in Table S1), nor did we detect evidence for differences in the sources of genetic and environmental influences between the sexes ($p = .67$; model 10 in Table S1). In other words, although women report greater jealousy than men do, the genetic influences on jealousy may be similar.

We did detect differences between the means of MZ and DZ twins ($p = .03$, $d = 0.09$; model 2 in Table S1), but, given the tiny nature of this

Table 2
Means (and standard deviations) of romantic jealousy per family member-by-sex-group as well as total (i.e., constrained to be the same across family members for men and women).

	Mean (standard deviation)
Twins MZ	
Men	4.91 (0.98)
Women	5.34 (0.99)
Twins DZ + DOS	
Men	4.82 (0.99)
Women	5.27 (1.00)
Siblings	
Men	4.72 (0.98)
Women	5.23 (1.00)
Total men	4.84 (0.99)
Total women	5.28 (0.99)

difference, we decided to not interpret it further, and we subsequently constrained MZ and DZ means as identical. Standard deviations could be constrained to be equal across MZ and DZ twin pairs, or across twins and sibling pairs (p = .95 and 0.99; model 3 and 5 in Table S1). We did not detect differences between twins and siblings (p = .09; model 4 in Table S1), or between dizygotic twin and sibling correlations (p = .33; model 8 in Table S1). Together, these results suggest that there are probably no twin contrast effects or twin-specific environmental influences on jealousy and that DZ twins are no more similar to each other in jealousy than other siblings are.

3.2. To what extent do genetic and environmental factors contribute to variation in jealousy?

The MZ twin correlation (r_{MZ} = 0.30) was more than double the DZ twin + sibling correlation (r_{DZ} + siblings = 0.08) (see Table 1), indicating the influence of non-additive genetic factors and no substantial influence of the familial environment. Indeed, an ACE model estimated the influence of the family environment to be zero, 95% CI [0–4] (see Table S1 for the fit of all models). Given that a DE model (i.e. non-additive genetic effects without additive genetic effects) is biologically implausible (Hill, Goddard, & Visscher, 2008), we report the broad-sense heritability (A + D) of the ADE model. This model indicated that 29% of variation in jealousy is explained by genetic factors (1% additive, 95% CI [0−20], 28% non-additive, 95% CI [3–35]), and 71% by non-shared environmental factors and measurement error, 95% CI [59–75].

3.3. What specific factors explain individual differences in romantic jealousy?

Correlations between jealousy and the predictors are shown in Table 3; sex-specific correlations are shown in Table S4. The regression analyses showed that greater jealousy was associated with having more restricted sociosexual attitude and sociosexual desire; with having been cheated on more often in the past and in the current relationship; with having lower mate value relative to the partner; and having less trust in the partner (see Table 4 for the results). We detected an interaction between sex and sociosexual desire on the level of jealousy, with the association being stronger in women than in men. We also detected an interaction between relationship status and both sociosexual attitude and desire: jealousy was more strongly associated with both sociosexual attitude and desire for individuals in a romantic relationship. No other interactions were significant (see Table 4).

3.4. Do these factors still influence romantic jealousy when controlling for familial confounding?

The follow-up discordant-twin analyses showed that, within monozygotic twins, the twin with a more restricted sociosexual desire experienced higher jealousy ($\beta = -0.18$, $p < .001$, $n = 455$), and the twin who rated their partner more trustworthy reported lower jealousy ($\beta = -0.15$, $p < .01$, $n = 224$ discordant twins) than his or her co-twin. The effects of sociosexual attitude ($\beta = -0.09$, $p = .08$; $n = 455$), having been cheated on in the past ($\beta = 0.08$, $p = .08$; $n = 196$), having been cheated on in the current relationship ($\beta = 0.02$, $p = .79$; $n = 17$), and mate value discrepancy ($\beta = 0.04$, $p = .50$, $n = 228$), were not significant when controlling for genetic and shared environmental confounding. However, the regression betas from the discordant-twin design analyses were similar in size to the betas from the regression analyses with the full

Table 3
Correlations (95% CIs), means and standard deviations of romantic jealousy and predictors. Univariate additive genetic (A) + non-additive genetic (D) (i.e., the broad sense heritability), shared environmental (C) and nonshared environmental (E) variance components for each predictor are reported at the bottom (univariate heritability). On the right, genetic and nonshared environmental influences on the covariance between jealousy with each predictor are displayed (bivariate heritability).

	1	2	3	4	5	6	7	Bivariate heritability	
								A	E
1. Jealousy	–							–	–
2. SOI attitude	−0.16 (−0.18;-0.13)	–						74% (39–100)	26% (0–61)
3. SOI desire	−0.20 (−0.22;-0.17)	0.43 (0.40;0.45)	–					29% (0–61)	71% (39–100)
4. Cheated on in the past	0.06 (0.03;0.09)	0.09 (0.06;0.12)	0.05 (0.01;0.07)	–				14% (0–97)	86% (2–100)
5. Mate value discrepancy	0.06 (0.02;0.09)	−0.10 (−0.13;-0.06)	−0.17 (−0.20;-0.14)	−0.00 (−0.03;0.03)	–			0% (0–17)	100% (82–100)
6. Trust in partner	−0.11 (−0.14;-0.07)	−0.05 (−0.07;-0.01)	−0.09 (−0.12;-0.06)	−0.16 (−0.20;-0.12)	0.06 (0.01;0.09)	–		11% (0–76)	89% (23–100)
7. Cheated on in current relationship	0.04 (0.00;0.07)	0.02 (−0.01;0.05)	−0.01 (−0.04;0.02)	0.19 (0.15;0.23)	−0.00 (−0.03;0.03)	−0.30 (−0.34;-0.24)	–	0% (0–38)	100% (62–100)
Mean (SD)									
Males	4.83 (0.99)	6.67 (2.06)	3.91 (1.77)	0.57 (1.16)	8.55 (1.57)	6.39 (0.97)	40/1276 (3%)		
Females	5.28 (1.00)	5.71 (2.36)	2.72 (1.46)	0.68 (1.34)	8.90 (1.77)	6.24 (1.08)	136/2569 (4.6%)		
Univariate heritability									
Broad sense heritability (A+ D)	29% (25–41)	43% (32–49)	32% (24–39)	23% (6–32)	29% (17–39)	12% (1–24)	0% (0–7)		
C	–	0% (0–7)	–	2% (0–14)	–	–	–		
E	71% (59–75)	57% (51–63)	68% (61–76)	75% (68–82)	71% (61–83)	88% (76–99)	100% (93–100)		

Table 4
Standardized regression coefficients (β) and *p*-values for main and simple effects of the regression analyses testing the effects of the predictor variables on romantic jealousy, including interactions with sex and relationship status. Simple effects are bolded if the two-way interaction was significant.

Predictor	Main effects	Simple effects			
		Relationship		Sex	
		Yes	No	Male	Female
Sociosexual attitude	−0.12 $p < .001$	**−0.16 $p < .001$**	**−0.06 $p < .01$**	−0.09 $p < .001$	−0.14 $p < .001$
Sociosexual desire	−0.14 $p < .001$	**−0.19 $p < .001$**	**−0.05 $p = .03$**	**−0.09 $p < .001$**	**−0.17 $p < .001$**
Cheated on in the past	0.04 $p < .01$	0.02 $p = .17$	0.06 $p < .01$	0.01 $p = .77$	0.05 $p < .001$
Mate value discrepancy	0.04 $p < .01$			0.03 $p = .33$	0.05 $p < .01$
Trust in partner	−0.08 $p < .001$			−0.06 $p = .02$	−0.09 $p < .001$
Cheated on in current relationship	0.03 $p = .03$[a]			0.05 $p = .07$	0.02 $p = .21$

[a] This beta is based on a comparison between individuals who had not been cheated on with individuals that had been cheated on (without cheating themselves) in their current monogamous relationship. When including, individuals who had been cheated on but also cheated themselves, the beta was 0.03, $p = .04$.

sample that werereported in Table 4. These co-twin control results should be interpreted in light of the far lower power in these analyses compared to the regressions using the full sample.

The bivariate twin analyses showed that the majority of the association between jealousy and the predictors was influenced by nonshared environmental factors (all estimates above 71%) and not by familial factors, with the exception of the association between jealousy and sociosexual attitude, which was mostly explained by genetic factors (74%) (see right side of Table 3).

4. Discussion

The current research aimed to shed light on why people differ in romantic jealousy. Our findings suggest that people differ in jealousy partly because of genetic influences, but mostly because of nonshared environmental influences. We did not detect an influence of the shared environment on jealousy. We also examined associations between jealousy and specific variables that have been hypothesized by mate-guarding accounts to influence jealousy proneness. Our findings provide some of the most robust evidence to date that mate value discrepancy, trustworthiness of a mate, and sociosexuality are associated with romantic jealousy.

Overall, 29% of variation in jealousy was attributable to genetic factors, with the remainder attributable to the nonshared environment. This genetic contribution to variation is on the low side compared to other psychological traits, including measurements of personality and emotions, for which the heritability is typically closer to 50% (Polderman, Benyamin, de Leeuw, et al., 2015). However, our finding is in line with those of Walum, Larsson, Westberg, Lichtenstein, and Magnusson (2013), who reported that sexual and emotional jealousy were 32% and 26% heritable, respectively. Also in line with Wallum et al., we found no evidence for sex differences in the magnitude of genetic and environmental influences on jealousy, or for different genetic or non-shared environmental influences operating in men or women. In other words, even though women reported higher jealousy than men, individual variation in jealousy within the sexes was influenced similarly by genetic and environmental factors.

The finding that familial environmental influences did not influence jealousy has theoretical implications. According to influential accounts of attachment theory, mental models of relationship expectations are transmitted from parents to children, through learning during infancy (Fonagy & Target, 2005; Van IJzendoorn, 1995; Verhage et al., 2016; c. f., Barbaro et al., 2017), and these mental models later determine emotion reactions, including jealousy, towards perceived relationship threats in adulthood (Mikulincer & Shaver, 2005; Sharpsteen & Kirkpatrick, 1997). Our finding that variation in jealousy is not influenced by familial environmental factors, which includes parenting, is inconsistent with these accounts. An implication is that research that seeks to understand variation in – and the development of – jealousy should attend more to genetic and nonshared environmental influences than to shared environmental factors such as parenting behavior. However, one caveat is that a limitation of twin studies is that they do not control for genetic and environmental interplay (for example, parental genes shaping the twin's family environment) which can confound the estimate of the influence of the family environment (Keller, Medland, & Duncan, 2010). Therefore, it is safest to say that we found no influence of the family environment 'independent of genetic factors' (Turkheimer, D'Onofrio, Maes, & Eaves, 2005).

In contrast to attachment theory's parental transmission account, mate-guarding perspectives hypothesize that jealousy should be primarily influenced by factors that increase the risk of infidelity by one's mate (Buss, 2013). These will often be socio-ecological variables (e.g., the attractiveness of one's mate, or the number of rivals in one's environment) which presumably derive more from the nonshared environment than the shared environment. Our finding of a substantial nonshared environmental influence on variation in jealousy is therefore consistent with mate-guarding accounts (though not uniquely consistent with those accounts). Note, however, that the estimate of the nonshared environment also includes measurement error.

The second aim of our study was to examine three of the variables predicted by mate-guarding accounts to influence jealousy: mate value discrepancy, cues to a mate's likelihood of infidelity (namely trust and actual experiences of infidelity), and sociosexuality. The strongest predictors of jealousy were more restricted sociosexual attitude and desire. Further, these relations were stronger for people in a relationship and for women. More sociosexually-restricted individuals may be more invested in fewer relationships and more motivated to protect them and, hence, experience more jealousy in response to cues to infidelity threats (Brase et al., 2014; Buss, 2013; Russell & Harton, 2005). Previous studies have most often not detected associations between jealousy and sociosexual orientation (Harris, 2003; Peters et al., 2014; Russell & Harton, 2005), but our findings were based on a much larger sample of individuals ($N > 7000$) than previous studies. The current finding was further strengthened by the discordant-twin design analysis within monozygotic twin pairs, which also detected a negative association between sociosexual desire and jealousy. This approach suggests that the association does not arise merely because sociosexual desire and jealousy emerge from the same genetic or family environmental sources. Results from the bivariate twin analyses were in accordance because they showed that nonshared environmental factors instead of familial factors explained the majority of the association (71%). Although it is therefore possible that restricted sociosexual desire causes higher jealousy, co-twin-control analyses cannot guarantee causal relationships or rule out reverse causation (McGue et al., 2010). Reverse causation (or bi-directional causation) is plausible, if, for example, individuals with higher jealousy pursue more exclusive relationships to reduce the possibility of infidelity by their mate.

Consistent with previous findings, people who reported being cheated on in the past, and those cheated on in their current relationship, also reported greater jealousy (Bendixen et al., 2015; Burchell & Ward, 2011; Edlund et al., 2006; Murphy et al., 2006; Sagarin et al., 2003). Additionally, having lower trust in one's partner was associated with higher jealousy (both on individual level and when we compared monozygotic co-twins discordant on trust in their partner). Therefore, findings suggest that variables assessing cues to a mate's likelihood of infidelity (trust and actual experiences of infidelity) relate to jealousy.

Also consistent with previous studies (Buss & Shackelford, 1997; Sidelinger & Booth-Butterfield, 2007), individuals who reported having a lower mate value than their partner reported higher jealousy. When examining associations within monozygotic twins only, those associations were non-significant (unlike associations between jealousy and sociosexual desire and mate trustworthiness), so the possibility that the association is due to similar genes influencing both mate value discrepancy and jealousy cannot be ruled out. However, the regression betas in the discordant twin design did not decrease in size, suggesting that the sample size of monozygotic twins may have been underpowered to detect an association. Moreover, the bivariate analyses did not detect familial influences on the association between jealousy and mate value discrepancy, indicating that the association between mate value discrepancy and jealousy is unlikely to be explained by similar genes or shared familial influences.

The study has some limitations. First, all measurements were based on self-reports. While the use of self-report questionnaires is common in psychology research (including most of the jealousy literature), they can be prone to measurement bias due to factors such as social desirability, which could, for example, have contributed to the low prevalence of cheating reported in our sample. Nonetheless, our self-report jealousy scale, which used 11 items describing jealousy-eliciting situations of varying severity, was likely to be a more sensitive measure of jealousy than measures commonly used. Many previous studies (e.g., Walum et al., 2013) have assessed jealousy with only two items asking participants how upset they would be in response to their partner's sexual infidelity and their partner's emotional infidelity. Another limitation was that the sample of discordant twin pairs contributing to the discordant-twin design analyses was much smaller than the sample in the overall regression analyses. Therefore, non-significant effects of sociosexual attitude, being cheated on in the past, and mate value discrepancy on jealousy within monozygotic twins could be due to lower power in these analyses. There are other potentially influential environmental variables that we were not able to assess in the current research. For example, perceived number and quality of rivals has been hypothesized to increase jealousy by increasing risks of cuckoldry or mate poaching (Buss, 2013; Pollet & Saxton, 2020), and perspectives other than the mate-guarding account propose that variables such as self-esteem are associated with jealousy (DeSteno, Valdesolo, & Bartlett, 2006). Future research on these factors using genetically informed studies would be valuable. Additionally, future research would benefit from using children-of-twins or nuclear twin designs that allow for the estimation of interplay between sources of variance that are impossible to disentangle using classical twin designs and might bias estimation of shared environmental influences (Keller et al., 2010).

In summary, this study confirms that people differ in jealousy partly because of genetic influences, but mostly because of nonshared environmental influences. Our findings provide some of the most robust evidence in support of several factors that have been hypothesized by mate-guarding accounts to influence jealousy proneness, and show that these factors similarly influence both men and women. Discerning the causes of variation in jealousy is an important step towards tackling the socially harmful consequences of jealousy, such as domestic violence and homicide.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Means, standard deviations and factor loadings of the 11 romantic jealousy items

Thinking about your feelings during all previous relationships, please rate how uncomfortable would you be if your partner did the following with an unrelated member of the opposite-sex…	Mean	Standard deviation	Factor loading
Provided/received emotional support	3.92	1.47	0.73
Conversational messages/emails	4.50	1.44	0.72
Complimented appearance	4.53	1.43	0.80
Touched while talking	4.55	1.32	0.70
Discussed your relationship issues	4.55	1.49	0.73
Ate a meal alone together	4.66	1.44	0.76
Flirtatious conversation	5.24	1.27	0.74
Talked about sex	5.26	1.43	0.81
Discussed romantic feelings for them	6.16	1.35	0.71
Kissed on the lips	6.46	1.20	0.66
Had oral or penetrative sex	6.62	1.12	0.60

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.evolhumbehav.2021.08.002.

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