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Jealousy: A Predictive and Explainable Model

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Abstract

O ciúme é uma resposta emocional complexa moldada por diferenças individuais nas estratégias de acasalamento, nas normas sociais e nos processos de autoavaliação. O presente estudo teve como objetivo predizer e explicar o ciúme por meio de uma abordagem de aprendizado de máquina combinada com valores SHAP, a fim de aumentar a interpretabilidade do modelo. Foi examinado um amplo conjunto de variáveis demográficas, psicológicas e relacionais, incluindo sociossexualidade, sexo, orientação sexual, religiosidade e autoestima. Os resultados indicaram que a sociossexualidade foi o preditor mais forte do ciúme, seguida pela heterossexualidade, religiosidade, autoestima e sexo. Interpretações evolutivas sugerem que o ciúme funciona como um mecanismo adaptativo de guarda do parceiro, moldado por trade-offs entre estratégias de acasalamento de curto e longo prazo e por riscos reprodutivos específicos de cada sexo. O maior nível de ciúme entre participantes heterossexuais parece ser impulsionado pela presença de consequências reprodutivas associadas a rivais do sexo oposto, enquanto a religiosidade esteve indiretamente associada a menores níveis de ciúme por meio de sua relação com atitudes sociossexuais mais restritas. Em contraste com grande parte da literatura existente, níveis mais elevados de autoestima estiveram associados a maior ciúme, achado que pode refletir o uso exclusivo de medidas de autoestima explícita e a influência de moderadores não mensurados. De modo geral, este estudo demonstra o valor de abordagens interpretáveis de aprendizado de máquina para integrar acurácia preditiva com teorias evolutivas e psicológicas, oferecendo novos insights sobre os determinantes do ciúme.
Palavras-chave: Ciúmes; Aprendizado de Máquina; SHAP; Orientação Sexual; Sexo; Sociossexualidade.

Abstract

Jealousy is a complex emotional response shaped by individual differences in mating strategies, social norms, and self-evaluative processes. The present study aimed to predict and explain jealousy using a machine-learning framework combined with SHAP values to enhance model interpretability. A broad set of demographics, psychological, and relational variables was examined, including sociosexuality, sex, sexual orientation, religiosity, and self-esteem. Results indicated that sociosexuality was the strongest predictor of jealousy, followed by heterosexuality, religiosity, self-esteem, and sex. Evolutionary interpretations suggest that jealousy functions as an adaptive mate-guarding mechanism, shaped by trade-offs between short-term and long-term mating strategies and by sex-specific reproductive risks. Higher jealousy among heterosexual participants appears to be driven by the presence of reproductive consequences associated with opposite-sex rivals, while religiosity was indirectly linked to lower jealousy through its association with more restricted sociosexual attitudes. Contrary to much of the existing literature, higher self-esteem was associated with greater jealousy, a finding that may reflect the exclusive use of explicit self-esteem measures and unmeasured moderating influences. Overall, this study demonstrates the value of interpretable machine-learning approaches for integrating predictive accuracy with evolutionary and psychological theory, offering new insights into the determinants of jealousy.
Keywrods: *Jealousy; Machine Learning; SHAP; Sexual Orientation; Sex; Sociosexuality.*

1 Introduction

Jealousy is typically defined in psychological literature as a complex emotional, cognitive and behavioral response triggered by the perception of a threat (actual or imagined) to a valued relationship or to one's possession of a valued relationship via a rival [1, 2, 3].

In children, jealousy may appear at the age of 6 months and show distress when their mother focuses her attention on lifelike dolls [4, 5]. On early adulthood, sexual differences appear as young mean shown more distress by a partner's sexual infidelity and young women show more distress by a partner's emotional infidelity [6]. In romantic/sexual relationships, jealousy triggered by the partner's sexual infidelity or rival sexual contact is sometimes distinguished from jealousy triggered by emotional involvement of the partner with a rival. Evolutionary theorists often emphasize this distinction

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[7, 8, 9].

One article investigated sex differences in jealousy but also included non-heterosexual and consensually non-monogamous (CNM) individuals [10]. While women exhibited higher overall and emotional jealousy than men, sex differences did not extend to non-heterosexual or consensually non-monogamous groups. Individuals engaged in CNM relationships reported lower levels of both overall and sexual jealousy, underscoring the influence of individual characteristics (such as gender and sexual orientation) and social contexts (such as relationship structure) on the experience of jealousy.

However, more broadly, long-term pair bonding in humans brings cooperative benefits, that include shared child-rearing, resources, and protection [11, 12, 13]. The threat of losing the partner or the partner diverting resources undermines reproductive success [11, 12]. Jealousy can function as a motivational system that triggers behaviors to guard against these threats by monitoring partner, deterring rivals, investing more in relationships [13, 14].

Jealousy can be manifested through behavioral reactions, such as vigilance/monitoring (mate-guarding), attempts to restrict partner's contact with others, direct rivalry, attempts at reassurance, sometimes aggression [15, 8]. Recently, one study found that the sequence may be: perceived threat → state jealousy feelings → compensatory behavior as a mate-retention effort [15].

In a twin study it was found sex effects on jealousy responses to infidelity type, such that men exhibited significantly stronger jealousy reactions to sexual infidelity than to emotional infidelity [16]. Structural equation twin models demonstrated significant genetic influences, with heritability estimates of 32% for sexual jealousy and 26% for emotional jealousy [16].

Recently Kupfer et al. (2022)[17] estimated genetic, shared environmental and nonshared environmental influences on jealousy. They found that jealousy was 29% heritable but the majority of variance is non-shared environmental (i.e., unique experiences). Shared environment (family upbringing/siblings) seems to contribute little in those studies (less than 29%). They found that 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.

Kupfer et al. (2022)[17] also found that the association between sociosexual attitudes (explained next) and jealousy was largely attributable to genetic influences (74%), whereas the remaining associations with jealousy were primarily explained by nonshared environmental (i.e., non-familial) factors, accounting for more than 71% of the variance.

1.1 1.1 Sociosexuality

Simpson and Gangestad (1991)[18], described individuals with higher sociosexuality or individuals that have an unrestricted sociosexual orientation, as those who typically engage in sex earlier in relationships, with multiple partners, and within relationships marked by lower commitment, emotional investment, and dependency.

Schmitt and colleagues (2005)[19], investigated sociosexuality in 48 nations and found that sex differences in sociosexuality were statistically significant in all 48 nations of the ISDP.

The average effect size was Cohen's d = 0.74, indicating a large and culturally robust difference, over twice the magnitude of a moderate effect (d = 0.50). ANOVA results showed that the effect of biological sex ($\eta^2 = 0.15$) was more than twice that of nation ($\eta^2 = 0.06$). Across countries, the size of the sex difference varied from small (Latvia, $d = 0.30$) to very large (Morocco = 1.24, Ukraine = 1.24, Bolivia = 1.20, Greece = 1.18, Philippines = 1.16).

The author also investigated cultural aspects, finding that greater political and economic gender equality was associated with smaller sex differences, as shown by negative correlations with:

- Gender Empowerment Measure ($r = -0.56$, $p \leq .001$).
- Women in Parliament ($r = -0.35$, $p \leq .001$).
- Women-Headed Households ($r = -0.54$, $p \leq .001$).

They also discovered that more demanding reproductive environments amplified sex differences:

- Low Birth Weight prevalence correlated positively ($r = 0.23$, $p \leq .10$).
- GDP per capita correlated negatively ($r = -0.35$, $p \leq .001$).

Together, gender equality and environmental harshness explained approximately 14% of the cross-cultural variance in sociosexual sex differences

Considering sexual orientation, it significantly predicted sociosexual behavior, $F(2, 12{,}893) = 49.78$, $p \leq .001$ [19]. Gay men and bisexual women reported the most unrestricted sociosexuality, consistent with the idea that gay men's elevated scores reflect interaction within a mating pool characterized by similarly unrestricted attitudes [19].

In another study, sociosexuality was included among several potential proximate mediators (such as attachment style and gender role beliefs) evaluated for their role in explaining sex differences in reactions to infidelity scenarios [20]. They tested the idea that unrestricted sociosexuality would be related to jealousy over sexual infidelity had been raised in the literature. However, the study found that sex differences in jealousy reactions were not mediated by reported sociosexual orientation [20].

Both female and male participants, sociosexuality was not significantly correlated with distress related to infidelity situations. For women, $r = -0.05$, $p =$ ns; for

men, $r = 0.03$, $p =$ ns. These results suggest that sociosexuality was unrelated to relative distress from sexual versus emotional infidelity across sexes [20].

1.2 1.2 SHAP Values (Shapley Additive exPlanations)

SHAP (SHapley Additive exPlanations) are a unified, game-theoretic approach to explaining model predictions that reconciles complex, accurate models with interpretability [21]. SHAP values attribute to each feature the change in the model's expected output when conditioning on that feature, showing how to move from the base value ϕ_0 (expected prediction with no features "present") to the actual prediction $f(x)$. See the equation below.

$$\phi_i = \sum_{S \subseteq F \setminus \{i\}} \frac{|S|!\,(|F| - |S| - 1)!}{|F|!} \left[f_{S\cup\{i\}}(x_{S\cup\{i\}}) - f_S(x_S) \right] \tag{1}$$

And the additive explanation model:

$$f(x) = \phi_0 + \sum_{i=1}^{M} \phi_i \tag{2}$$

SHAP values satisfy an additive explanation model, in which the prediction for an instance x is expressed as the sum of a baseline value and the individual feature contributions. Specifically, the model output $f(x)$ can be decomposed into the expected prediction ϕ_0, representing the average model output in the absence of any feature information, plus the sum of the SHAP values of all M features. This additive formulation provides a transparent and interpretable explanation of individual predictions, as each SHAP value ϕ_i represents the contribution of feature i to the deviation of the prediction from the baseline.

SHAP is the unique additive feature attribution method that satisfies local accuracy, missingness (null features get zero attribution), and consistency (if a feature's contribution never decreases under a model change, its attribution does not decrease) [21]

The study of jealousy is important for understanding how biological, emotional, psychological, and sociocultural factors shape affective reactions to relational threats. When examining jealousy, studies generally do not consider variables like sexual and sociosexual orientation. It is not yet known exactly which variables and interactions most affect jealousy. Using "interpretable" machine learning, like SHAP values, together with psychological scientific knowledge, we can identify risk patterns, profiles of greater vulnerability, and mechanisms that regulate conflicts and partner retention behaviors, contributing to both theory and practice in psychology.

2 Aim

Our aim is twofold:

1. Predict jealousy.
2. Explain jealousy through the contribution (SHAP value) of each variable.

3 Methods

Participants were recruited in Brazil using a snowball sampling approach, drawing from lists of previous participants, online announcements targeting homosexual and bisexual communities, as well as postings in the university journal and the São Paulo State Journal. Data collection was concluded after approximately one month.

A total of 5152 individuals were analyzed, mean age of 28.4 (SD = 9.36) and mostly female (82%, N = 4233). Most participants are heterosexuals (77.3%, N = 735), followed by bisexuals (14.3%, N = 735) and homosexuals (8.5%, N = 427).

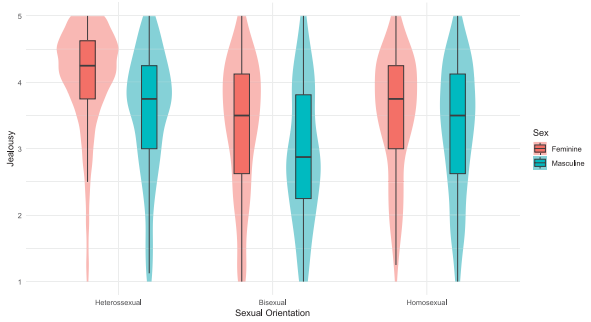

Figure 1: Box-violin plot of jealousy.

3.1 Measures

3.1.1 Jealousy

Participants completed the Reactive Jealousy subscale of the Revised Anticipated Sexual Jealousy Scale (RASJS)[22], which asks respondents to rate, on a 5-point scale, how upset they would feel if a partner engaged in behaviors such as flirting or having sex with someone else.

We used the version validated for Portuguese speakers [23], with minor adaptations to Brazilian Portuguese. To broaden the content coverage, we added three items: "How would you feel if your partner fell in love with someone else?", "How would you feel if your partner had sexual fantasies about someone else?", and "How would you feel if your partner hugged someone else?".

The expanded scale showed good internal reliability (Cronbach's $\alpha = 0.85$). Because analyses produced equivalent results using both the original and expanded versions, we report findings based on the expanded scale. We also did a Confirmatory Factor analysis, with the following results CFI = 0.872, TLI = 0.821, RMSEA = 0.168, SRMR = 0.075, $\chi^2(20) = 2915.90$, $p < .001$.

3.1.2 Sexual Orientation

Sexual orientation was assessed on a 7-point Kinsey scale (Kinsey et al., 1948) ranging from 0 (exclusively heterosexual) to 6 (exclusively homosexual). Individuals on positions 0–1 were pooled into a "Heterosexual" group, positions 2–4 were grouped into a "Bisexual" group and positions 5–6 were pooled into a "Homosexual" group.

3.1.3 Sociosexual Orientation

Sociosexual orientation (or sociosexuality) was assessed using the revised Sociosexual Orientation Inventory [24]. The scale asks about the number of partners the participants had, their feelings about sex without emotional commitment, and fantasies about sex. We used the 9-point scale with 9 questions, validated for the Brazilian population [25]. In our study, Cronbach's α0.84 and CFI: 0.971 TLI: 0.957 RMSEA: 0.069 SRMR: 0.044 $\chi^2(24) = 620.42$, $p < .001$.

3.1.4 Self-esteem

The shortened version of the Self-esteem scale was used, developed by Buunk (1982)[26]. The scale uses a 4-point method, from "strongly agree" to "strongly disagree" and was adapted by Dini et al. (2004)[27]. Some questions are reverse coded and include "On the whole, I am satisfied with myself", "I feel that I have a number of good qualities" and "I certainly feel useless at times". In our study Cronbach's $\alpha = 0.89$ and CFI: CFI: 0.926 TLI: 0.905 RMSEA: 0.1 SRMR: 0.042 $\chi^2(35) = 1834.48$, $p < .001$.

3.1.5 Sexual Desire

Participants rated five items, that were used by Lippa (2006)[28] and derived from Spector et al. (1996)[29]. Their Sexual Desire Inventory 2 (SDI-2) was validated by Cartagena-Ramos et al. (2024)[30].

Items included are "I have a strong sex drive", "I frequently think about sex", "It doesn't take much to get me sexually excited", "I think about sex almost every day", and "Sexual pleasure is the most intense pleasure a person can have". Participants chose their degree of disagreement or agreement with the items on a 7-point scale that ranged from strongly disagree to strongly agree. In our study Cronbach's $\alpha = 0.893$ and CFI: 0.97 TLI: 0.939 RMSEA: 0.119 SRMR: 0.031 $\chi^2(5) = 370.03$, $p < .001$.

3.2 Model

We modeled reactive jealousy using the continuous score `CLS_score` as the dependent variable. The following psychological scales were included as numeric predictors:

- `AE_score` — self-esteem;
- `DS_score` — sexual desire;
- `SOI_score` — sociosexuality;
- a dummy variable for relationship status (`status_solteiro`; 1 = single, 0 = in a relationship or missing).

Additionally, the following categorical variables were included:

- `DD5_group` — grouping based on religious status;
- `Sexo` — sex;
- `Orientacao_Sexual` — sexual orientation.

The original variable `relationship_status` was used only to construct the binary indicator `status_solteiro` and was not entered directly into the model.

3.2.1 Data preprocessing

All analyses were conducted in R version 4.5.0 [31]. Cases with missing values on the outcome variable (`CLS_score`) were removed, whereas participants with missing predictor values were retained.

For numeric predictors (`AE_score`, `DS_score`, `SOI_score`, `status_solteiro`):

- missing values were imputed using the median of the training set for each variable;
- the same medians were applied to impute missing values in the test set.

For categorical predictors (`DD5_group`, `Sexo`, `Orientacao_Sexual`):

- missing values were recoded into an explicit `Missing` category, allowing missingness itself to be modeled;
- factor levels in the test set were aligned with those in the training set.

We then applied one-hot encoding (dummy coding without intercept) to all predictors using model.matrix, so that each category was represented by a separate binary column. After encoding, all predictors were standardized (mean = 0, SD = 1) based on the training data; the same centering and scaling parameters were applied to the test data.

A Spearman correlation matrix between the outcome and standardized predictors was computed in the training set to provide an initial, purely bivariate description of associations, but this correlation matrix was not used for variable selection (all pre-specified variables were kept in the model). See the correlation matrix below (Figure 2).

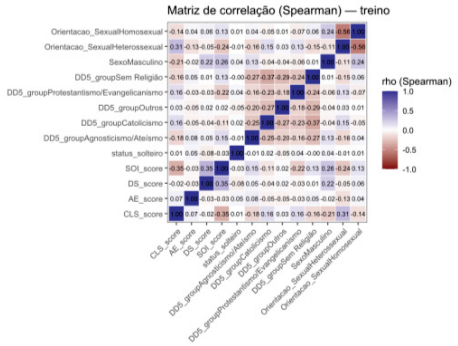

Figure 2: Spearman Correlation Matrix.

3.2.2 Train–test split and validation

To evaluate out-of-sample performance, we used a hold-out design. The dataset was randomly split into 70% training and 30% test sets. Within the training set, we further created an internal validation split where 80% of the training data was used for model fitting and 20% for hyperparameter tuning and early stopping.

The hyperparameters and the number of boosting iterations were selected using only the training/validation data. The final performance metrics reported below are based exclusively on the held-out test set that was not used for tuning.

3.2.3 Model specification (XGBoost)

We used gradient boosted decision trees implemented in the XGBoost library to predict jealousy. This is a non-linear, ensemble learning method that builds a sequence of shallow decision trees. Each tree focuses on correcting the errors of the previous ones. The full equation can be seen below.

$$\mathcal{L} = \sum_{i=1}^{n} l(y_i, \hat{y}_i) + \sum_{k=1}^{K} \Omega(f_k) \tag{3}$$

The additive tree model:

$$\hat{y}_i = \sum_{k=1}^{K} f_k(x_i), \qquad f_k \in \mathcal{F} \tag{4}$$

And the regularization term:

$$\Omega(f_k) = \gamma T + \frac{1}{2}\lambda \sum_{j=1}^{T} w_j^2 \tag{5}$$

In the XGBoost framework, $l(y_i, \hat{y}_i)$ denotes the loss function measuring the discrepancy between the observed outcome y_i and the predicted value $\hat{y}_i$. The term $\Omega(f_k)$ represents the regularization component, which penalizes model complexity to reduce overfitting. Each function f_k corresponds to a decision tree that is learned iteratively and added to the ensemble in order to minimize the residual errors of the previous prediction.

In the regularization term, T denotes the number of leaves in the tree, w_j represents the weight associated with leaf j, γ controls the penalty for the number of leaves, and λ controls the L_2 regularization on leaf weights.

3.2.4 Hyperparameter tuning

To reduce overfitting and optimize predictive performance, a random search was conducted over a predefined hyperparameter grid. The candidate set included the following values:

- learning rate (`eta`): 0.02, 0.05, 0.10;
- maximum tree depth (`max_depth`): 3, 5, 7;
- row subsampling (`subsample`): 0.70, 0.85, 1.00;
- column subsampling (`colsample_bytree`): 0.70, 0.85, 1.00;
- minimum loss reduction (`gamma`): 0, 0.1, 0.3;
- minimum child weight (`min_child_weight`): 1, 3, 5;
- L_2 regularization (`lambda`): 0, 1, 3;
- L_1 regularization (`alpha`): 0, 0.5, 1;
- objective function: `reg:squarederror` or `reg:pseudohubererror`.

From the full grid, $N_{\text{TRIES}} = 30$ hyperparameter combinations were randomly sampled. For each combination, a model was trained for up to 3,000 boosting iterations using the training subset for model fitting and the validation subset for performance evaluation. Model performance was assessed using the root mean squared error (RMSE).

Early stopping was applied with a patience of 200 boosting rounds:

- training was stopped if the validation RMSE did not improve for 200 consecutive iterations;
- the lowest validation RMSE and the corresponding optimal number of trees (`best_iteration`) were recorded.

The best-performing configuration on the validation set was as follows:

- objective function: `reg:pseudohubererror`;
- learning rate (`eta`): 0.05;
- maximum depth (`max_depth`): 3;
- row subsampling (`subsample`): 0.85;
- column subsampling (`colsample_bytree`): 0.70;
- minimum loss reduction (`gamma`): 0.1;
- minimum child weight (`min_child_weight`): 5;
- L_2 regularization (`lambda`): 0;
- L_1 regularization (`alpha`): 0;
- optimal number of boosting iterations: `best_iteration` = 53, with a validation RMSE of 0.80.

Using these tuned hyperparameters, the final model was refitted on the full training set (70% of the data) using 53 boosting iterations.

4 Results

Predictions were generated for the held-out test set (30% of the data). Model performance on the test set was evaluated using the root mean squared error (RMSE), mean absolute error (MAE), and the coefficient of determination (R^2), yielding RMSE = 0.799, MAE = 0.611, and $R^2 = 0.22$.

As a simple baseline, model performance was compared against a mean-only predictor, in which each test observation was assigned the average `CLS_score` of the training set. Baseline performance was $\text{RMSE}_{\text{base}} = 0.904$ and $\text{MAE}_{\text{base}} = 0.698$.

Relative to the baseline model, the XGBoost model reduced prediction error by approximately 11.6% in RMSE and 12.5% in MAE:

$$\frac{0.904 - 0.799}{0.904} \approx 0.116 \tag{6}$$

$$\frac{0.698 - 0.611}{0.698} \approx 0.125 \tag{7}$$

Overall, the model explained approximately 22% of the variance in reactive jealousy in the unseen test data ($R^2 = 0.22$).

4.1 Model interpretation: SHAP values and feature importance

To interpret the contribution of each predictor, we used SHAP (SHapley Additive exPlanations) values via the shapviz package. We computed SHAP values for all training observations. For each predictor, we calculated the mean absolute SHAP value (average SHAP value) as a global importance measure: larger values indicate that the variable tends to have a stronger impact on the prediction (on average), regardless of direction. The top five most relevant variables were sociosexuality (`SOI_score`), being heterosexual, without a religion, self-esteem (`AE_score`) and sex. Table 1 shows the average absolute SHAP Value.

Table 1: Mean absolute SHAP values for the top predictors.

Variable	Mean SHAP value
`SOI_score`	0.29
`Orientacao_SexualHeterossexual`	0.20
`DD5_groupSem Religiao`	0.07
`AE_score`	0.06
`SexoMasculino`	0.06

The beeswarm plot (Figure 3) depicts the direction of the variables. As lower sociosexuality, being heterosexual (as opposed to bisexual and homosexual), not having a religion (as opposed to having one or being agnostic/atheist), having higher self-esteem, and being female (as opposed to male), explain jealousy better.

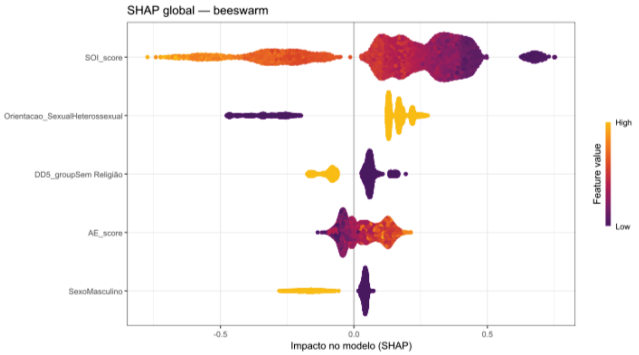

Figure 3: Beeswarm plot.

5 Discussion

We aimed to predict and explain jealousy through machine learning and SHAP values. We found that sociosexuality explains jealousy the most, followed by heterosexuality, religion, self-esteem and sex.

Peters et al. (2014)[32], did a "daily diary study", exploring daily feelings of jealousy and found that sociosexuality is implicated in how individuals react to feelings of jealousy. They found an increased reactivity, meaning that sociosexuality acts as a moderator, meaning that while it may not influence the occurrence of jealousy, it strongly impacts the intensity of the subsequent emotional responses. When participants experienced higher than usual jealousy, this feeling was linked to heightened feelings of rejection and anger. This relationship was significantly strong for sexually restricted participants.

More recently, Kupfer et al. (2022)[17] found that greater jealousy was significantly associated with having a more restricted sociosexual attitude and sociosexual desire, like the results in our study, and that women also report greater overall jealousy. Evolutionary we can explain three out of our five main results. Together with sociosexuality, sex, specifically being female, and heterosexuality come into play.

Individual differences in sociosexuality reflect evolved mating strategies shaped by trade-offs between reproductive benefits of short-term mating and the fitness advantages of long-term pair bonding, parental investment, and partner retention [33, 34]. Restricted sociosexuality is evolutionarily associated with greater commitment to long-term relationships because monogamous bonding historically increased offspring survival through biparental care, resource provisioning, and protection against rival conspecifics [33, 35, 36].

In this context, and by looking at sex differences, reflecting our results, jealousy acts as an evolved mate-guarding mechanism designed to mitigate the adaptive costs of infidelity, including paternity uncertainty for males and diversion of partner investment for females

[7, 8, 37].

Sex differences in jealousy reflect asymmetric reproductive risks, such that men evolved heightened sensitivity to sexual infidelity due to the threat of cuckoldry, whereas women evolved heightened sensitivity to emotional infidelity due to the threat of loss of resources and commitment [7, 8]. Men's comparatively unrestricted sociosexuality, on average, reflects lower obligatory parental investment and greater historical reproductive payoffs from mating effort, whereas women's more restricted sociosexuality reflects selection pressures favoring choosiness and partner reliability [33, 19, 38].

However, when considering the result that heterosexuals experience greater jealousy, we should consider a distinction in jealousy patterns that are attributed to the presence of reproductive consequences. Specifically, the risk of conception with a rival, which is characteristic of heterosexual pairings.

When comparing jealousy reactions, differences between sexual and emotional jealousy cues often disappeared or were greatly reduced in non-heterosexual contexts [23, 39]. The unique pattern of higher sexual jealousy in males is generally specific to the configuration of a male with a female partner. In a study of bisexual participants, who imagined both male and female partners, bisexual males responded similarly to heterosexual men only when responding about a female partner but scored significantly lower on sexual jealousy when responding about a male partner [10].

Men and women may not differ significantly in their jealousy response patterns when the rival was of the same sex as the partner [39]. This effect suggests that jealousy functions to secure reproductive investments and avoid costs that specifically occur when an opposite-sex rival is present [39].

Jealousy is hypothesized to be activated to the degree that a rival poses a viable threat [11]. For heterosexual males, this most viable threat is sexual infidelity involving a rival male (paternity threat) [40]. For heterosexual females, the deepest threat is emotional commitment to a rival female (investment loss) [11].

While there is no definitive evidence that heterosexuals are consistently more jealous in a general sense, their jealousy response is uniquely and robustly conditioned by the threat of reproductive loss tied to the opposite sex. But we do see sex differences and combined with sociosexuality, we can see why heterosexual male jealousy is highly sensitive to sexual infidelity, and why heterosexual female jealousy is highly sensitive to cues of resource and commitment loss.

Regarding self-esteem, we surprisingly found that higher and not lower self-esteem best explain being more jealous, contrary to previous findings. Rydell Bringle (2007)[41], found that individuals that display higher jealousy have lower self-esteem. Similarly, Stieger et al. (2012)[42] employed multiple measures of romantic jealousy and self-esteem (explicit and implicit), identifying both sex-specific and measurement-specific effects.

Explicit self-esteem includes habitual and conscious actions, representing an individual's conscious belief in their own worth [42], typically measured by questionnaires like the ones used in our study. Implicit self-esteem on the other hand reflects how positively or negatively the self is automatically associated with affective evaluations [42]. For example, faster reaction times when pairing "self" (e.g., me, mine) with positive words (good, valuable) than with negative words. higher levels of jealousy can be associated with lower explicit self-esteem among men, but not women, whereas among women higher jealousy was associated with higher implicit self-esteem [42].

Another study by Chin et al. (2017)[43], found that self-esteem was related to jealousy and Dark Triad traits (narcissism, Machiavellianism and psychopathy). The author also explain that jealousy may vary as a function of their associations with the Dark Triad, and self-esteem may exert a moderating effect on the relationship between jealousy and Dark Triad traits.

Although we did not measure implicit/explicit jealousy and Dark Triad traits, it could be that there is an influence of Dark Triad traits and since our sample is composed mostly by women and lower explicit self-esteem that predicts greater jealousy in men, this pattern did not reflect our results.

Finally, we found that not having a religion (i.e., not being atheist/agnostic, Catholic, Protestant or otherwise), was the third best variable that explains jealousy. Although studies generally do not measure jealousy and religion or religiosity directly, we find that religiosity is associated with lower sociosexuality and behavioral patterns that align with more restricted sexual attitudes and behaviors [44, 45, 46, 47].

In a recent study by Ciocca et al. (2024)[44], they found that the general factor of sociosexuality was negatively related to religiosity. The relationship between religiosity and lower sociosexuality can be explained by underlying psychological factors. Religiosity predicts increased sexual guilt and is negatively associated with the search for sexual pleasure and proneness to sexual fantasy, which in turn diminishes sexual behavior [46]. Moreover, the prevailing sexual lifestyle endorsed by many major religions centers on procreative sexual activity within heterosexual marriage [48]. Monotheistic religions like Islam, Judaism, and Christianity typically proscribe sexual activity outside of heterosexual marriage [48].

This reflects a socially monogamous style, where in humans it can be understood as an outcome of strategic behavior in resource allocation, particularly where inherited resources (like land) would be depleted if divided among the offspring of multiple wives [49]. Social monogamy can also be a stable strategy if females grant husbands higher paternity (fidelity) in exchange for exclusive investment of resources in their offspring [49]. Norms promoting high paternity (such as ideologies of sexual fidelity) were common in Eurasian agrarian societies, which may have helped establish social monogamy [49].

Considering Christians, our largest group if we con-

sider Catholics and Protestants together, Fortunato Archetti (2010)[49] explain that while the text links Christian norms to the spread of monogamous marriage restrictions, it does not explicitly state that religion causes monogamy as a political system but rather observes that religious beliefs reinforce restrictions on non-marital and non-monogamous sexual behavior.

6 Conclusion

The objectives of the present study were to predict and explain individual differences in jealousy using a machine-learning framework, complemented by SHAP values to enhance interpretability. By combining predictive modeling with theoretically informed interpretation, we sought not only to identify which variables best explain jealousy, but also to clarify how these factors align with established evolutionary and psychological theories. The results indicate that sociosexuality is the strongest explanatory factor, followed by heterosexuality, religion, self-esteem, and sex.

These findings are largely consistent with evolutionary perspectives on mating strategies and jealousy as an adaptive mate-guarding mechanism. Restricted sociosexuality, female sex, and heterosexual orientation are all associated with greater sensitivity to reproductive and investment-related threats, which helps explain heightened jealousy in these groups. Religiosity appears to operate indirectly by promoting more restricted sociosexual attitudes and monogamous norms, which historically supported long-term pair bonding, parental investment, and resource stability.

Nonetheless, several limitations should be noted. The cross-sectional design limits causal inference, and the reliance on self-report measures, particularly for self-esteem, may obscure distinctions between explicit and implicit processes. Additionally, the absence of measures of implicit self-esteem, Dark Triad traits, and differentiated components of jealousy constrains interpretation, and the predominantly female sample may have influenced some associations. Future research should incorporate longitudinal designs, broader personality assessments, and more diverse samples to further clarify the mechanisms underlying jealousy.

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