Mapping the Conceptual Space of Jealousy

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Abstract Evolutionary approaches to the study of romantic jealousy have principally been guided by the idea that there are two types of threats to romantic relationships—sexual and emotional—and that these two affect men and women's fitness differently. While this approach has garnered considerable empirical support, it has not investigated the full conceptual domain of jealousy. To do so, we employ techniques developed by cognitive anthropologists and psychologists. Correspondence analysis of similarity judgments among jealousy-inducing exemplars reveals that threats to romantic relationships are spontaneously categorized along three plausibly adaptive dimensions: how severe they are, whether they suggest the presence of a specific rival, and whether they imply deception by the romantic partner. This pattern of results is consistent across men and women, younger and older adults, and those with differing infidelity experience. The full conceptual landscape of jealousy highlights considerations that have been previously overlooked by researchers relying exclusively on sexual selection theory. [Cognition, Emotion, Psychological Anthropology, Sex]

"If we truly believe that emotions are the result of the way people construe and evaluate what is happening, then the most useful theory will be based on those construals and evaluations, inasmuch as they are what, psychologically speaking, causes the emotions." – Richard Lazarus

The study of emotions and the events eliciting them has a long history (Ellsworth and Scherer 2003). Modern approaches—particularly appraisal theory and evolutionary psychology—have explicitly outlined the pathways between the elicitor and the emotive response (Arnold 1960; Lazarus 1966; Mesquita and Frijda 1993; Pinker 1997; Plutchik 1980; Tooby and Cosmides 1992). Both appraisal and evolutionary approaches agree that the elicitors of emotion have affective valence and that the resulting emotions motivate behavior aimed at reaping benefits or mitigating harm (Ellsworth and Scherer 2003; Lazarus 1991; Gaulin and McBurney 2001; Osgood 1964). Appraisal theory focuses on the evaluative processes that assign valence (Dohle et al. 2012; Gutierrez and Giner-Sorolla 2007; Kuppens et al. 2003; Scherer 1997; Tracy and Robins 2006), whereas evolutionary psychology emphasizes the adaptive function (sensu Darwin 1859) of particular valence/context pairings (Buss et al. 1992; Sell et al. 2009; Sznycer et al. 2012). Thus, the two theoretical approaches agree that emotions involve appraisals of contexts by their possible effects on the individual and motivate adaptive responses to those contexts but focus on different aspects and causes of the emotional appraisal.

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In the evolutionary psychology literature, romantic jealousy is one of the most intensively studied emotions. There it is considered a negative emotion that motivates both attention to and mitigation of threats to romantic relationships (Buss et al. 1992). Current theory assumes that romantic threats signal one of two distinguishable losses—loss of sexual exclusivity and loss of emotional exclusivity—and, further, that men and women will evaluate (sensu Lazarus 1991) these losses differently. Specifically, men will be more distressed than women by loss of sexual exclusivity, and women will be more distressed than men by loss of emotional exclusivity (Buss et al. 1992). The overwhelming majority of evolutionary research on jealousy has considered only this predicted sex difference (see Sagarin et al. 2012 for a recent review and meta-analysis).

While the sex-difference component of the hypothesis has received considerable support, it is not without critique. For example, the forced-choice methods typically used—requiring participants to decide which is worse: a partner's sexual infidelity or a partner's emotional infidelity—reliably produce the sex difference, whereas alternative response modes may not (see DeSteno et al. 2002; Harris 2005). Moreover, there are questions about whether these two infidelities are ordinarily disassociated in real-world situations (Berman and Fraizer 2005; Harris 2003; Tagler 2010; cf. Edlund et al. 2006). Here we offer an additional critique, one central to an evolutionary view of jealousy: no evidence has yet been offered that the human mind, left to its own devices, carves relationship threats into distinct sexual and emotional components. While few evolutionary researchers have explicitly claimed that the sexual-emotional distinction is the sole or primary distinction organizing romantic threat perceptions, the literature is dominated by studies designed to look for sex differences along this dimension, using stimuli that assume its reality and salience (e.g., Buunk and Dijkstra 2004; De Souza et al. 2006; Cramer et al. 2001; Easton et al. 2007; Levy and Kelly 2010; Thompson et al. 2007; Sagarin et al. 2012; Sagarin and Guadagno 2004; Shackelford et al. 2000).

We suggest that identifying the primary components of jealousy will clarify several outstanding questions about the adaptive design and function of jealousy. Are "sexual" and "emotional" principal components of jealousy, or do humans spontaneously parse jealousy in some other way? If so, what are its components, and how might they track particular fitness risks? How stable are the components of jealousy across individuals who differ by sex, age, or relationship experience? The study reported here attempts to describe the conceptual space of jealousy by answering these various questions.

To do so, we exploit graphical representations of similarity-judgment data, a methodological approach that is well established in many domains of anthropology and psychology (Albert 1991; Alvard 2009; Boster 1986, 1987; Bhushan et al. 1997; Campo et al. 2008; Cliff and Young 1968; Hermann and Raybeck 1981; Parrott and Smith 1993; Romney et al. 1997; Tronvoll 2011; Weller 1986) but that has been little used by evolutionary psychologists (see Singh and Luis 1995 for an exception). This methodology is ideally suited to describe the conceptual space of jealousy because it reveals the components of this emotion as it is instantiated in the minds of the informants, with minimal

researcher-imposed constraints or prior hypotheses canalizing informants' responses (Jaworska and Chupetlovska-Anastasova 2009; Romney et al. 1997; Ryan and Bernard 2003; Torgerson 1965; and citations listed above). For example, graphical representations of similarity judgments of surface texture have revealed a consistent set of (implicit) organizing components, regardless of the sensory modality in which the texture stimuli are presented (Bhushan et al. 1997; Picard et al. 2003; Yoshioka et al. 2007). Moreover, each of these components correlates with the activation of particular populations of neurons in both humans (Puce et al. 1996) and macaques (Arcizet et al. 2008). Such results suggest that graphical representations of similarity judgments can accurately reflect distinctions implicit in the minds, and perhaps brains, of informants. In other words, we chose to use graphical representation of similarity judgments because, while remaining "relatively free of specific theoretical demands, [this technique] 'uncovers' or 'recovers' the hidden structure that is in the data" (Bhushan et al. 1997:242).

Methods

Overview

The present study was undertaken in five phases: (1) exemplars of events inducing jealousy were nominated, and 24 were selected to cover the greatest possible conceptual range with a manageable number of stimuli; (2) informants judged the similarity of the exemplars; (3) the judged similarity of exemplars by different subpopulations of participants and by all the participants as a whole was graphically represented both as hierarchical trees and as multidimensional plots; (4) the three principal dimensions of these plots were evaluated with subsequent rating tasks, in part, to determine whether they represented sexual and emotional threats; and (5) the jealousy spaces of different subpopulations were compared.

Participants

Phase 1: Nomination of jealousy-inducing exemplars. 226 men (mean age = 20.12 ± 6.24, range = 18–41) and 406 women (mean age = 20.86 ± 5.93, range = 18–47) were given extra credit in an undergraduate anthropology course for nominating a romantic-jealousy-inducing situation. Sexual orientation of the nominators was not assessed.

Phase 2: Similarity judgment. 200 heterosexual participants judged the similarities among the jealousy-inducing exemplars via the successive pile sort, described below. The sample is grouped by sex and age; 45 younger men (mean age = 19.92 ± 0.74, range = 18–21), 72 younger women (mean age = 20.25 + 0.75, range = 18–21); 41 older men (mean age = 25.65 ± 4.97, range = 22–42), and 42 older women (mean age = 25.93 ± 5.07, range = 22–41). All younger participants are university undergraduates; all older participants are nonundergraduate residents of the same city as the undergraduates. Twenty-nine participants reported having been sexually unfaithful to a partner (11 men, 18 women); 34 participants reported having been emotionally unfaithful (16 men, 18 women); 36 participants suspected that a past or current partner had been sexually unfaithful to them (18 men,

18 women); and 35 participants suspected that a past or current partner had been emotionally unfaithful (22 men, 13 women). Undergraduate participants received course credit for participation; older community participants were not compensated.

Phase 3 was analytical only.

Phase 4: Characterizing the dimensions of the jealousy space. 448 participants (mean age = 23.35 ± 2.032; 217 men, 231 women) performed these rating tasks. Participants were undergraduates or community members who did not participate in phases 1 or 2. Undergraduates received extra credit for participation; community members were not compensated. Sexual orientation of the raters was not assessed.

Phase 5 was analytical only.

Protocol

Phase 1: Nomination of jealousy-inducing exemplars. To construct an instrument that was both appropriate for this study population and relatively free of researcher-imposed bias, stimuli were created by the participants. Participants in this phase were asked: "Please think of a romantic relationship that you are in, have had, or would like to have. Briefly describe something your partner could do or say—or fail to do or say—that would make you jealous. This could be a little jealous, very jealous, or something in between." Most of the 632 nominated exemplars might induce jealousy. However, six were more consistent with envy (i.e., no potential romantic loss was mentioned; for example, "My partner saw someone famous on the street"). Because romantic jealousy is the sole focus of this study, these six exemplars were removed.

In the exemplar-nomination phase, neither the presence nor absence of sex differences speaks to the goal of our study. In latter phases (see below), these exemplars are structured by participants to reveal the conceptual space of jealousy; only then can we identify the components spontaneously used to organize threats to romantic relationships and note any sex differences. In other words, we use free listing as a *tool* to explore the primary components of jealousy; the free list is the flashlight, not the space revealed by its light. Nonetheless, we note some sex differences in exemplar nomination. Among the remaining 626 exemplars, the *content* of nominated exemplars did not obviously differ by sex or age. Of note, a partner's sexual infidelity and a partner's emotional infidelity were each nominated multiple times by both men and women, as well as by younger and older participants. However, post hoc analysis revealed that the frequency of nominating *severe* sexual threats was greater for men than for women (see Results section for specification of "severe" threats; 39 nominations by men, 25 nominations by women, $\chi^2 = 19.65$, $p < 0.001$). The frequency of nominating *severe* emotional threats did not differ between men and women (six nominations by men, 13 nominations by women, $\chi^2 = 0.15$, $p > 0.05$).

After eliminating many redundant exemplars, 47 of the original 626 were determined to be sufficiently distinct.[1] To further reduce the number of exemplars in a principled way, seven

preraters who did not participate in any other phases of the study completed a successive pile sort (see below) with these 47 candidate exemplars. Correspondence analysis (CA; see below) of these preliminary similarity judgments produced a plot of the 47 candidate exemplars in a preliminary "jealousy space." Using this plot, we reduced the number of exemplars to 24 by selecting the smallest subset of exemplars that maximally spanned the space (i.e., exemplars that either occupied a unique region or were on the edge of the data cloud). Since the goal of this study is to identify the components of jealousy rather than to confirm a hypothesis, we strove to retain the full diversity of nominated exemplars. Thus, the range of jealousy-inducing exemplars was spanned with minimal redundancy[2] and cognitive burden on Phase 2 participants. See Note 3 for the 24 final jealousy exemplars.

Phase 2: Similarity judgments. The successive pile-sort method (Boster 1986, 1987, 1994) was used to elicit participant's judgments of similarity among the exemplars. We used a successive pile sort, rather than a free pile sort or triad task, because it elicits an equal number of fine-grained contrasts from all participants. In this task, each jealousy exemplar is printed on its own index card, and all 24 cards are presented to a participant in random order. The participant is then asked to sort the exemplars into as many groups as desired, using whatever similarity criteria he or she chooses after being told "there are no right answers; we just want to know what you think." The participant is also asked to provide, for each group, "a brief name or label that describes the group." Following that, the participant is asked to merge the two most similar groups and provide a new name for the merged group. This combine-and-name step repeats until all exemplars are in a single group. Each participant is then presented with his or her original groups and asked to split the group containing the most dissimilar exemplars into two groups. Splitting of groups continues until each exemplar constitutes its own group.

Phase 3: Graphical representations of the jealousy space. The successive pile sort elicits a complete binary tree from each participant in which the number of splits from the root of the tree needed to separate a pair of exemplars is the measure of their similarity. The resulting similarity matrices are represented both by average-link hierarchical clustering trees (Fig. 1, Supporting Information Fig. S1) and by CA plots (Fig. 2, Supporting Information Fig. S2). For clarity, the trees shown here are reduced, with only the first five major splits displayed; for the various subpopulations studied here, these splits were more clearly defined than later ones. Reducing the trees in this way necessarily leaves six major groups.

CA performs a simultaneous factoring of the rows and columns of a matrix so that both can be represented in the same low-dimensional space (Greenacre 1983). A CA of a symmetrical matrix produces a solution similar to principal components analysis, because the row scores and the column scores are the same. Also, as in principal components analysis, CA dimensions are ordered by the amount of variance they explain. Thus, in this study, the primary component dictating how threats are perceived is reflected by the x-axis; the

secondary component is reflected by the y-axis, etc. As in most plots that assign Cartesian coordinates to cases, proximity indicates similarity.

Phase 4: Interpreting the dimensions of the jealousy space. Axes of multidimensional scaling or CA plots are often interpreted intuitively by the researchers, based solely on inspection of the spatial array of exemplars, with no attempt to empirically validate these interpretations. We decided an additional step was necessary for two reasons. First, because researchers might not classify threats to romantic relationships in the same fashion as nonacademics (Haslam and Bornstein 1996; Parrott and Smith 1993), we preferred a more emic approach. Second, because the purpose of this study is to evaluate the presence of sexual and emotional components in the absence of researcher-imposed biases, we deemed it both appropriate and fair to rely on our participants' judgments, rather than our own. Therefore, the meanings of the CA dimensions were objectively assessed by evaluating the degree to which the exemplars' coordinates on each dimension correlate with independent ratings of the exemplars on six particular qualities. Three of these qualities were chosen to match prior theorizing about jealousy by evolutionary psychologists, and three were chosen in the normal way, by inspecting the CA plot.

Thus, Phase 4 participants rated the degree to which each of the 24 jealousy exemplars indicated: (A) sexual infidelity, (B) emotional infidelity, (C) position on a sexual infidelity-emotional infidelity continuum, (D) severity of threat, (E) rival specificity, and (F) deception by the romantic partner. Scales A–C were inspired by our desire to evaluate the salience of the sexual-emotional distinction that has been emphasized in prior evolutionary research on jealousy (e.g., Sagarin 2012). Thus, to allow confirmation of a sexual-emotional distinction, participants rated sexual threat and emotional threat independently (on the possibility that these jealousy components are orthogonal) and also rated sexual versus emotional threat along a continuum (on the possibility that these components are related but distinct at the extremes). Scales D–F were suggested by an inspection of the CA plot. Participants then rated the extent to which each of the 24 exemplars fit each of these six qualities, using six-point Likert scales. Wording for the scales was as follows:

A. Sexual infidelity: "If your partner did this, would it indicate that your partner is having a sexual relationship with someone else?" (anchored with "Definitely no" and "Definitely yes").
B. Emotional infidelity: "If your partner did this, would it indicate that your partner has a strong emotional bond with someone else?" (anchored with "Definitely no" and "Definitely yes").
C. Sexual infidelity-emotional infidelity continuum: "If your partner did this, would it indicate that your partner has an exclusively sexual relationship with someone else, an exclusively emotional relationship with someone else, or a relationship with someone else that has both sexual and emotional elements?" (anchored with "Exclusively sexual" and "Exclusively emotional").

D. Threat severity: "If your partner did this, how serious a problem would it be for your relationship?" (anchored with "Not a problem" and "Very big problem")
E. Rival specificity: "If your partner did this, would you think (s)he is generally uncommitted to you or interested in another particular individual?" (anchored with "Generally uncommitted" and "Interested in particular individual").
F. Deception: "If your partner did this, would you think (s)he was being sneaky or open?" (anchored at "Open and honest" and "Sneaky and dishonest").

Phase 5: Comparing the jealousy spaces of subpopulations. Several contrasts between participant subpopulations were evaluated: men compared to women; younger compared to older; participants who had been sexually (or emotionally) faithful compared to unfaithful participants; and participants whose partners had been sexually (or emotionally) faithful compared to those with unfaithful partners. Men were compared to women because previous theory and research has devoted the greatest attention to the prospect of sex differences, as discussed above. There were two reasons to contrast the responses of young undergraduates with those of somewhat older community members. The first is to address the critique that psychological research depends too heavily on university undergraduates who do not respond as more mature adults would (cf., Tagler 2010). The second reason to contrast the responses of younger and older individuals is that they are in different phases of their reproductive careers. This supposition was supported: younger participants were in less-committed relationships as compared to older participants (single or casually dating versus seriously dating, engaged, or married; $F = 35.349$, $p < 0.001$). Finally, we evaluated claims that infidelity experience affects the perception of jealousy-inducing events (Buss and Shackelford 1997; Sagarin et al. 2003). As in earlier studies, we distinguish between participants whose partners were or were not sexually or emotionally unfaithful (Edlund et al. 2006; Guadagno and Sangarin 2010; Sagarin et al. 2003; Tagler 2010). However, we also distinguish between participants who themselves had and had not been sexually or emotionally unfaithful (cf. Schutzwohl 2008).

Assessments of *both* similarities and differences between subpopulations rely on (1) summarizing each participant's pile-sort judgments with an individual 24-by-24 exemplar similarity matrix, (2) collapsing these matrices into aggregate subpopulation matrices, and (3) comparing the matrices using the Quadratic Assignment Program (QAP) (Hubert and Schultz 1976). Each cell in the individual similarity matrix contains the integer reflecting the judged similarity between two exemplars (e.g., the split level separating the two exemplars).

To assess *similarity* between comparison subpopulations, the individual similarity matrices of those in the same subpopulation (e.g., all women) were averaged, creating a single 24-by-24 aggregate matrix. The resulting aggregate matrices of any two subpopulations (e.g., men versus women) are then compared using QAP. In this fashion we address the question: Do these two subpopulations generally agree on the pattern of similarity among these threats to romantic relationships?"

To assess *differences* between subpopulations, we again begin with individual similarity matrices; however, they are collapsed in a different manner. Here, they are used to create a participant-by-participant correlation matrix where each cell represents the correlation between the individual similarity matrices of the two participants. For this study, the correlation matrix is 200-by-200, and each participant's judgments are compared to all other participants' judgments. Again using QAP, we compared the correlation matrix to a model matrix with 1s corresponding to participants in the same population (e.g., two women) and 0s corresponding to participants in different populations (e.g., a man and a woman). By comparing the correlation matrix to the model matrix, we address the question: "Are the differences between members of two comparison populations greater than the differences among members within a single comparison population?"

For tests of both significant similarities and significant differences, QAP comparisons were evaluated with a *z*-statistic and, more directly, with Monte Carlo simulations. QAP-*z* scores reflect the agreement between the compared matrices and are evaluated similarly to traditional *z*-scores. Monte Carlo simulations count the percent of times a random permutation in the compared matrices results in greater similarity between the two. Because the matrices being compared are not the same in tests of similarities and tests of differences, QAP can be used for both. In tests of *similarities*, a random permutation of a matrix may alter the perceived similarity between threat exemplars; in tests of *differences*, a random permutation of a matrix may alter whether a pair of participants is accurately classified as being from the same subpopulation. For a 5% tolerance of a Type I error, the observed data must be more similar to random permutations 95% of the time. One million permutations were used in each comparison.

We also made comparisons between the reduced trees of comparison subpopulations. Differences in the configuration of the trees were made using the Fowlkes-Mallows index (Fowlkes and Mallows 1983; see Nemec and Brinkhurst 1988 on the use and interpretation of inferential tests comparing dendrograms). Additionally, thematic analysis of the group names provided by participants during the sorting task was used to indentify salient qualities of relationship threats (Lacey and Luff 2007; Ryan and Bernard 2003).

Results

Description of the Exemplar Groups and the Overall Jealousy Space

We used a CA plot, a reduced tree, and the names participants provided for their pile-sort groups to identify jealousy components for all participants considered together. The overall reduced tree (Supporting Information Fig. S1) identified the major groups as DIP, CEFJKW, LMNVX, BOQRS, AGH, and TU. These groups range in severity from mild threat (group DIP) to severe threat (groups AGH and TU). The severe

exemplars are similar to those used as stimuli in other evolutionary psychology studies (severe emotional exemplars: AHG; severe sexual exemplars: TU). The major exemplar groups are also observable by their clustering in the CA plot (Supporting Information Fig. S2). The range in severity is evident as a gradation across the x-axis, as discussed below.

Is jealousy best characterized by its sexual and emotional components?

If jealousy were best characterized by its sexual and emotional components, the sexual and emotional ratings (scales A and B from Phase 4) would each correlate highly with one or the other of the first two dimensions from the overall CA plot (previous theory is agnostic regarding which would be the primary dimension); but this is not the case. The first dimension correlates positively with *both* the sexual ($r = 0.869$, $p < 0.001$) and emotional ratings ($r = 0.694$, $p < 0.001$), and the second dimension correlates with neither sexual ($r = 0.311$, *ns*) nor emotional ($r = 0.096$, *ns*) ratings (Supporting Information Table S1).

Another possible interpretation of previous theorizing about jealousy is that sexual and emotional threats do not constitute independent dimensions but instead represent a single continuum, with exclusively sexual threats at one end and exclusively emotional threats at the other. Scale C (from Phase 4) was designed to assess this possibility. Ratings of exemplars on this scale fail to correlate significantly with the first dimension ($r = 0.394$, *ns*). However, the sexual-emotional continuum ratings are significantly correlated with second dimension scores ($r = 0.497$, $p < 0.05$), as discussed below.

What is the best description of the first dimension of the CA plot?

In Phase 4, we also collected three additional ratings, scales D–F (severity, rival specificity, and deception by the partner) that were suggested by our inspection of the overall jealousy space. As detailed below, these three ratings provide a better characterization of its main dimensions.

The first dimension of the CA plot explains 17.6% of the variance; it is most highly correlated with Scale C's severity ratings ($r = 0.948$, $p < 0.001$; Supporting Information Table S1) and not correlated with the specificity ratings (scale E, $r = -0.026$, *ns*) or with deception ratings (scale F, $r = 0.204$, *ns*). As mentioned above, this first dimension is also highly correlated with both sexual and emotional ratings. However, the severity ratings are more highly correlated with exemplar position on the x-axis (0.948 vs. 0.869 and 0.694) and fully mediate the first dimension's relationship with both the sexual ($b = 0.055$, *ns*) and emotional ratings ($b = -0.049$, *ns*), suggesting that severity provides the best description of this first dimension of the jealousy space. In other words, when participants consider a threat to romantic relationships, they attend to its degree of severity rather than its sexual or emotional nature.

What is the best description of the second dimension of the CA plot?

The second dimension of the CA plot explains 9.3% of the variance; it is correlated with Scale D's specificity ratings ($r = 0.661$, $p < 0.001$; Supporting Information Table S1), Scale E's sexual-emotional continuum ratings ($r = 0.497$, $p < 0.05$), and Scale F's deception ratings ($r = 0.572$, $p < 0.01$). None of these correlations are significantly different from each other. Of these three rating scales, only deception ratings and sexual-emotional continuum ratings are significantly correlated with each other ($r = 0.481$, $p < 0.05$), and deception ratings fully mediate the relationship between the second dimension and sexual-emotional continuum ratings ($b = 0.288$, *ns*). This suggests rival specificity and deception are better descriptors of the second dimension of the jealousy space than are any of the three sexual/emotional scales (A–C).

What is the best description of the third dimension of the CA plot?

The third dimension explains 8.7% of the variance; it is correlated only with deception ratings ($r = -0.629$, $p = 0.001$; Supporting Information Table S1).

Is one's view of jealousy-inducing threats affected by one's sex?

Yes. Participants agree significantly more with members of their own sex than with the opposite sex (QAP $z = 2.93$, Monte Carlo = 0.99; Supporting Information Table S2). This sex difference is most clearly reflected in the different shapes of the reduced trees (Figs. 1a and 1b), suggesting women attend more to the specificity of a rival than do men, and men attend more to the severity of the threat than do women. At the same time, men's and women's overall views of jealousy are very similar (all QAP $z = 14.92$, Monte Carlo = 1.000). This is demonstrated by the similar positions of exemplars in the CA plot comparing the jealousy spaces of men and women (Fig. 2). CA can be used to make multiple comparisons at once; in this case, we compared similarity in judgments between men and women while simultaneously comparing similarity among exemplars. If differences were mostly due to sex and very little to do with the qualities of the exemplars, men's judgments would be to one side of the CA plot and women's would be to the other. This segregation is not present, indicating sex is not the main organizer of exemplars. Instead, exemplar position is mostly due to the differing features of the exemplars themselves.

Like the overall jealousy space, men's jealousy space and women's jealousy space were best described by severity, specificity, and deception. There are no significant sex differences in strength of correlation between exemplar coordinates and their ratings for the first three dimensions (all ps > 0.400)

Is one's view of jealousy-inducing threats affected by one's age?

Yes. Participants agree significantly more with members of their own age class than with the other age class (QAP $z = 2.22$, Monte Carlo = 0.980; Supporting Information Table S2). This age difference is reflected in the differing shapes of the trees in Figures 1c and 1d. In particular, younger participants make a significantly stronger distinction between severe

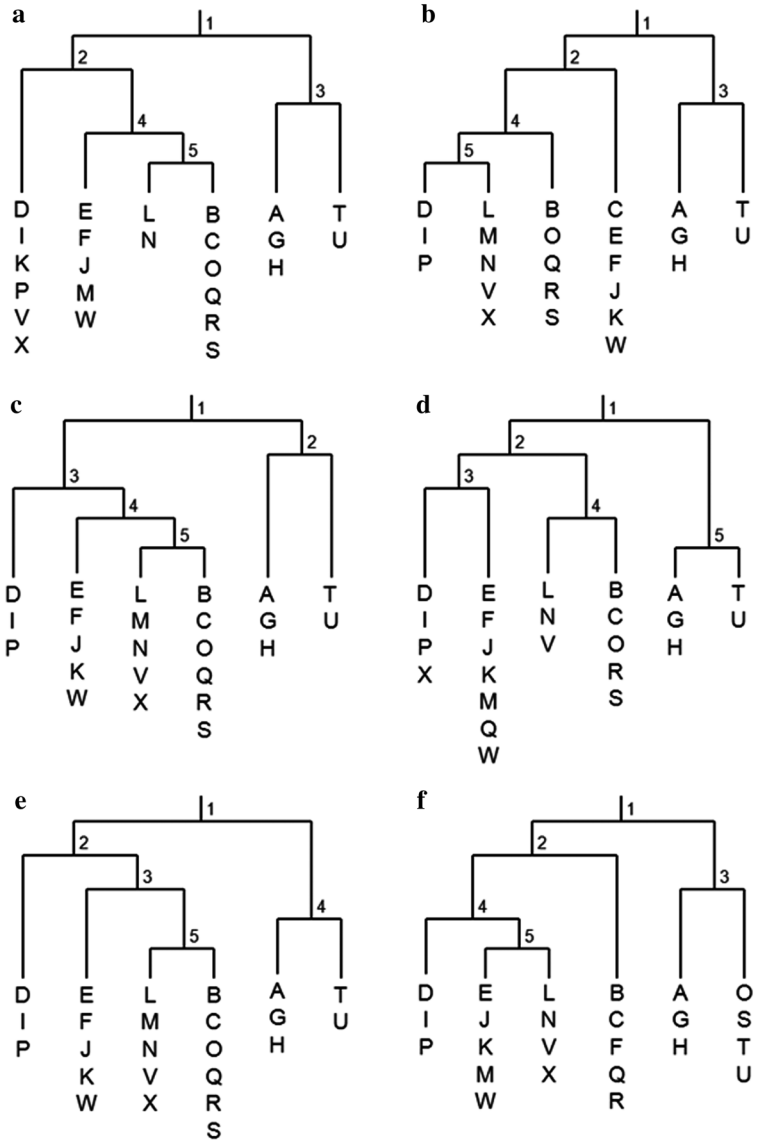

Figure 1. Reduced trees for men (a) and women (b), younger (c) and older (d), sexually faithful (e) and sexually unfaithful (f). Letters represent threat exemplars and numbers represent the sequence of splits between them.

sexual threats and severe emotional threats than do older participants (Fowlkes-Mallows index = 0.00; Fowlkes and Mallows 1983). However, the overall view of jealousy by younger and older participants is very similar (QAP Z = 14.36, Monte Carlo = 1.000).

Is one's view of jealousy affected by one's prior sexual infidelity?

Yes. Participants agree significantly more with participants who share their history of sexual fidelity (QAP $z = 1.86$, Monte Carlo = 0.960; Supporting Information Table S2). This difference between the sexually faithful and unfaithful participants is reflected in the different

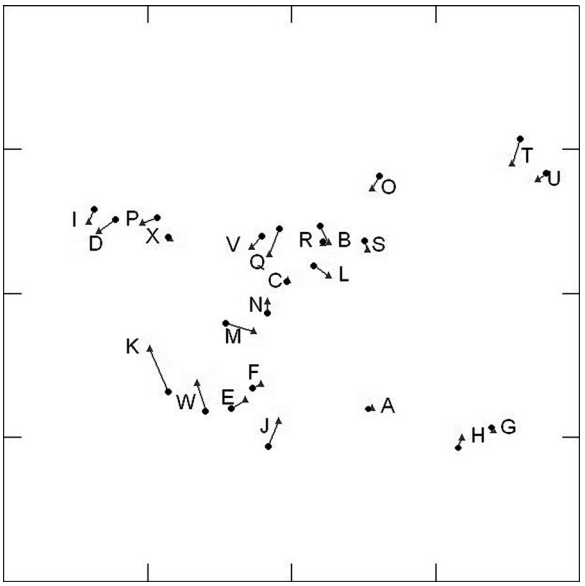

Figure 2. Composite correspondence analysis plot comparing men's and women's judgments. Triangles indicate men's judgments of exemplars; circles indicate women's judgments of exemplars. For each exemplar, a line connects average male and female judgments. Line lenghts indicate degree of agreement between men's and women's perception of a particular exemplar; thus a short line indicates that men and women view an exemplar similarly.

shapes of the trees in Figures 1e and 1f. However, again, the overall view of jealousy by the sexually faithful and unfaithful are very similar (QAP $z = 13.72$, Monte Carlo = 1.000).

Is one's view of jealousy affected by other aspects of one's infidelity history?

No. Participants did not agree significantly more with others who shared their experience of partner's sexual or emotional infidelity or with others who shared their own history of emotional infidelity (all QAP $z \leq 1.05$, Monte Carlo ≤ 0.85; Supporting Information Table S2). The views of jealousy by all three pairs of these subpopulations are very similar (QAP $z \geq 14.13$, Monte Carlo = 1.000).

The Nature of Romantic Jealousy

Evolutionary approaches to the study of romantic jealousy have been guided by the idea that there are two distinct types of threats to a romantic relationship—sexual and emotional. Thus, most prior researchers have created stimuli explicitly designed to be either sexual or emotional in content. While this approach has succeeded in uncovering predicted sex differences, it has necessarily neglected questions about the wider conceptual landscape of jealousy and the relative salience of the sexual/emotional components vis-à-vis other elements of that landscape. Here we show that, when participants are presented with a more open-ended task—similarity judgments of exemplars nominated by others like

themselves—the components of jealousy are threat severity, rival specificity, and deception by the partner.

Based on the strength of the correlations and patterns of mediation among the ratings (Phase 4), the primary component of jealousy is best characterized as threat severity. In bivariate terms, this dimension is also significantly *positively* correlated with *both* the sexual infidelity and the emotional infidelity ratings. This pattern is highly inconsistent with previous theorizing, which postulates that sexual and emotional threats vary independently and pose distinct challenges. Our data suggest that, if subjects are not presented with stimuli that spotlight this distinction, they do not spontaneously recognize a sexual-emotion dichotomy but instead see these threats as varying in parallel. Moreover, the first dimension is most strongly correlated with severity, and severity completely mediates the relationship between the first dimension and *both* the sexual and emotional ratings. In other words, participants attend to the severity of the threat, not its sexual or emotional nature.

Similarly, the overall reduced tree (Supporting Information Fig. S1) and the reduced trees of all subpopulations (Fig. 1) show participants first distinguish severe from nonsevere exemplars and only much later distinguish severe-sexual from severe-emotional exemplars. These patterns do not overturn previous jealousy research, but they do suggest that a distinction between sexual and emotional threats is not a primary component of people's spontaneous assessment of romantic threats. These patterns further imply that sex differences in response to romantic threats have been overstated in the existing evolutionary psychology literature.

The primacy of severity in similarity judgments is not only quantitatively reflected in the reduced tree and in the CA plot but also qualitatively in participants' names for their exemplar groups. The low-threat group (exemplars DIP) caused little concern for most participants (e.g., "Probably nothing"; "Shouldn't get mad"). Conversely, participants considered severe-threat groups (exemplars AGH and TU) quite serious, and the names of these groups reflected intense concern (e.g., "Unforgivable"; "The relationship is over"). Severity is a novel consideration in jealousy research, but it is consistent with the emotion's hypothesized adaptive function. Threats to a romantic relationship require appropriately calibrated behavioral responses. Severe threats merit urgency and strong countermeasures. Less severe threats must be attended to commensurately to avoid undue stress on the relationship (e.g., aggressive confrontation, incessant mate guarding).

Again based on the strength and pattern of the bivariate correlations and mediations, the second dimension of the jealousy space is most strongly correlated with rival specificity. Names for the exemplars were consistent with this interpretation. When considering low-specificity groups, participants were more likely to focus on interpersonal problems (exemplars CEFJKW: "Complete lack of interest in me"; "Lack of respect"); when considering high-specificity groups, participants were more likely to suspect a particular rival's presence (exemplars DIP, LMNVX, and BCOQRS: "There is another woman"; "Aware of

another woman"; and "Interested in another man"). The presence or absence of a specific rival is also a novel consideration in jealousy research, and it too is plausibly adaptively salient. While the first dimension signals the magnitude of the necessary response, this second dimension directs the behavioral response: should it monitor the partner because he/she is loosely bonded, or should it be aimed at a specific rival who might be repelled or undermined with targeted strategies (cf. Buss et al. 2000; Buunk and Dijkstra 2004; Buunk et al. 2011; Dijkstra and Buunk 1998, 2002)? Given this proposed function, this component may be especially salient in cultures where mate switching or sexual infidelity is comparatively easy.

Both the second and third dimensions of the jealousy space were correlated with deception ratings. Names for the exemplar groups were consistent with this interpretation. For both dimensions, exemplars AGH comprised the low-deception group; these exemplars were considered upsetting but honest ("Explicit statements of disinterest"; "Honest"). Exemplars comprising the high-deception group were different for the second and third dimensions of the jealousy space. In the second dimension, the high-deception group comprised exemplars TU. Independent ratings confirm these exemplars are both deceptive and indicate the presence of a specific rival; however, when considering this group, participants overwhelmingly focused on their partner's involvement with a rival ("Definitely wants to be with another man"; "Cheating"). In other words, participants were less concerned that the actions were deceptive and more concerned about whom the actions involved. Interpretation of the third dimension was more straightforward: this dimension was only correlated with deception ratings, and names for the high-deception group clearly reflected participants' attention to dishonesty (group BOQRS: "Untrustworthy"; "Things I would pay special attention to"; "Very suspicious"). Like severity and specificity of rival, deception by a partner suggests an adaptive basis. Implications of infidelity—occurring before any confirmation of its occurrence—should motivate increased attention to the partner's behavior, whereabouts, and associates. As succinctly put by a participant, deceptive acts require special attention.

Between-Subpopulation Variation

There is considerable overall agreement between participant subpopulations in their similarity judgments of jealousy exemplars, as indicated by the QAP-z and Monte Carlo values. Men's judgments are quite similar to women's; younger participants' judgments are quite similar to older participants'; judgments of those with a history of infidelity are quite similar to those without. Agreement between subpopulations is also shown in the pairs of reduced hierarchical trees (Fig. 1) where many of the exemplar groups are recognized by all subpopulations. (For example, exemplars DIP form a high-specificity, low-severity group in all of the hierarchical clustering trees.) This overall similarity is notable considering the fact that most evolutionary research has focused on differences rather than similarities between subpopulations (e.g., sex differences). Nonetheless, there were many nuanced, yet significant, differences between subpopulations' constructions of the jealousy space.

Men Compared to Women

Some sex differences in judgment of the jealousy-inducing exemplars are apparent in men's and women's reduced trees (Fig. 1a and 1b). Men were more attentive than women to subtle differences in the severity of the 19 nonsevere exemplars, dividing them into a low-threat group (exemplars DIKPVX) and two moderate-threat groups (EFJMW and BCLNOQRS). Women were more attentive than men to indications of a specific rival, dividing nonsevere exemplars into a low-specificity group (CEFJKW) and high-specificity groups (DIP, LMNVX, and BOQRS). There were no apparent sex differences in attention to deception indicated by the reduced trees.

Sex differences were also present in exemplar groups' names. Those given to the low-threat group suggested men were more upset by these exemplars than were women (men: "Probably nothing" and "Mysterious behavior"; women: "Female friend" and "Doesn't mean anything"). Considering moderate threat groups, names did not indicate sex differences in distress; however, there were sex differences in foci. Men focused on how the threats would make them feel ("Uncomfortable feelings"; Trying to make me jealous") whereas women were more likely than men to relate the threats to faults in the relationship ("Commitment not good"; "Neglecting me"). Nonsevere threats to romantic relationships such as these are rarely studied by evolutionary psychologists (cf. Schutzwöhl 2005), and therefore qualitative data presented here are especially informative.

Sex differences in judgments of five severe threats (AHG and TU) were expected based on evolutionary theory and prior research (cf. Buss et al. 1992; Daly and Wilson 1982). Names given to severe sexual and severe emotional-threat groups supported this notion: Men seemed more upset by severe sexual threats than did women, and women seemed more upset by severe emotional threats than men did. However, comparing men's and women's jealousy spaces (Fig. 2) highlights that differences between sexes are quite small compared to differences between exemplars.

Younger Compared to Older Participants

When considering moderate-threat groups (EFJKW and LNV), younger participants provided names indicating more anxiety and distress than older participants did (younger: "Suspicious of something physical"; "I don't want you to see him"; older: "Slightly annoying"; "Maybe bad"). There were no apparent age differences in distress when considering either low-threat or severe-threat groups. However, the distinction between severe sexual (TU) and severe emotional (AGH) groups was significantly more salient for younger participants than it was for older participants. This is evident in the different shapes of the younger and older participants' reduced trees (Fig. 1c and 1d). Likewise, this distinction is apparent in the names given to the severe sexual threats: older participants were much more likely to consider sex as a component of a romantic relationship than were younger participants (younger: "Cheating"; "I hate you"; older: "Most serious offences to the relationship"; "Relationship definitely over"). This pattern suggests that the distinction between sexual and emotional threats may have been overestimated in the literature on

the adaptive basis of jealousy because younger participants have predominated in earlier research.

Comparison between Sexually Faithful and Sexually Unfaithful Participants

Considering all subpopulations studied, the jealousy space of sexually unfaithful participants was the most divergent from the overall jealousy space. The shape of sexually unfaithful participants' reduced trees suggests most exemplars are not very threatening (i.e., more closely related to exemplars DIP than BOQRS in Fig. 1f). Similarly, sexually unfaithful participants' names for all groups of exemplars were relatively emotionally detached or blasé compared to names given by sexually faithful participants (unfaithful: "You bug me" and "I kind of care"; faithful: "Definite red flags" and "Purposefully hurting me").

Strengths, Limitations, and Conclusions

This study was designed to describe the conceptual space of jealousy in a manner that allowed for identification of distinct sexual and emotional components but did not presuppose them. Given our participant-driven methods, the data provide a more complete description of the conceptual space of romantic jealousy than has prior research, which has either been narrowly focused on the possibility of sex differences or, conversely, explored the broader conceptual space comprising both jealousy (romantic and otherwise) plus envy (Haslam and Bornstein 1996; Parrott and Smith 1993; Salovey and Rodin 1986). In addition, our results suggest a possible adaptive basis for the components identified: attend to the magnitude of the threat, and implement appropriate counterstrategies targeted at the rival or the romantic partner. This provides a blueprint for replication and extension in other populations.

We believe this study also illustrates how a narrow reliance on an etic, exclusively theoretical, approach can produce a limited understanding of a topic. This is particularly true when the topic is human cognition (cf. Romney and Moore 1998). By constructing an instrument based on participants' nominations, our study revealed components never before suggested by evolutionary psychologists.

Of course, this study has limitations. Relying on participants to generate exemplars requires them to recall or predict circumstances that could elicit jealousy in a romantic relationship. However, we believe that we were able to mitigate these limitations by collecting candidate exemplars from more than 600 people, aged 18 to 47.

In selecting the final set of exemplars, we gathered a wide range of participant-nominated, jealousy-inducing exemplars while reducing redundancy among them. The resulting 24-exemplar set has led to the identification of three jealousy components that, at minimum, reflect the views of our youthful North American participants. These three components—severity, specificity of rival, and deception by partner—are consistent with the view that jealousy functions to avoid harm to romantic relationships, a view shared by appraisal

theory and evolutionary psychology. Further research with culturally appropriate stimuli are needed to evaluate how well these components apply to other populations. Replications in cultures that have little mate switching or divorce, infrequent mixed-sex social interactions, or allow polygyny would be particularly valuable.

Because this study was designed to evaluate a hypothesis that anchors a large literature in evolutionary psychology, we were especially concerned to minimize our own researcher bias. This led us to take precautions—such as acquiring ratings for the jealousy space dimensions—that are typically neglected. It is possible that some unintended bias affected the thematic analysis of the group names. Egregious distortions are unlikely because the quantitatively derived reduced trees firmly constrain thematic interpretations. It is also possible that the initial elicitation and selection of exemplars was biased in some fashion, but given that the reduction of candidate exemplars to the final suite of 24 was based on their position in the preliminary jealousy space—not on exemplar content—any bias should have been minimized.

Since our principal goal was to describe the jealousy space—particularly to explore the extent to which it is organized by a distinction between sexual and emotional threats—we chose to work with the population most heavily used by evolutionary psychologists in documenting this sex difference: young North Americans. Cultural variation in courtship norms, sexual autonomy, acceptance of divorce, and permissible interaction between men and women all might affect perception of threats to romantic relationships. We consider this project only the first step in identifying the adaptive components of jealousy and recognize the need for further studies in other cultures. To that end, we have begun replication in South America.

We acknowledge that our community participants were significantly, but not considerably, older than our university participants. However, members of these subpopulations were in different phases of their reproductive careers. The significant differences between older and younger subpopulations—particularly in the distinction of sexual threats from emotional threats—are consistent with the difference in reproductive-career phase. As with other aspects of this study, further research can evaluate how similar the jealousy space of our older subpopulation is to the jealousy spaces of other adult populations.

Finally, a reviewer accurately noted that the difference between those who have and have not been sexually faithful may be due to individual differences in sociosexuality (Simpson and Gangestad 1991). Our data do not allow us to test this hypothesis, but we encourage others to incorporate the Sociosexuality Inventory (Simpson and Gangestad 1991) into any replication studies.

There are many further questions posed by our results: What additional dimensions of jealousy space might there be? Do similarities in perception of threat result in similarities in associated behavioral responses? Why do women focus more on specificity of a romantic rival than do men? Why do men focus more on severity of threats than women? Why does one's

own sexual infidelity—but not other kinds of infidelity experience—affect one's perception of the jealousy space? What other demographic differences affect one's view of jealousy? What features of a threat lead it to be regarded as severe? How does the sociocultural milieu affect perception of threats to romantic relationships? Do severity, specificity, and deception reflect a human universal parsing of the jealousy space, or are they particular to certain populations?

In sum, this study shows that the conceptual space of jealousy is best defined by the severity of threat, specificity of rival, and deception by the partner, in that order of importance. Moreover, the differences between subpopulations are slight in comparison to their broad agreement on the nature and structure of the jealousy space. Prior research across a wide range of conceptual, cognitive, and perceptual domains suggests that the method used here can provide insights into the organization of diverse concepts. If its application in this realm is similarly informative, it may help scientists to appreciate the full functional scope of relationship jealousy.[3,4]

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Notes

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1. For example, the candidate exemplars—"I caught my boyfriend kissing another girl" and "My boyfriend made out with someone else at a party"—were considered redundant. Conversely, the candidate exemplars—"My boyfriend mentioned an ex-girlfriend and that they had a strong connection" and "My boyfriend compares me to his ex"—were considered distinct threats and were further evaluated. We erred on the side of caution and subjected all nominated exemplars that seemed unique to further analysis.

2. The candidate exemplars listed below occupied a similar space in the preliminary CA. The first two exemplars were retained because they were most distant within the cluster; the last four were omitted from subsequent analyses. Other exemplars were retained or omitted in a similar fashion.

"You find out from a friend that your partner had dinner with an ex-girlfriend."
"Your partner mentions an ex-girlfriend and that they had a strong connection."
"Your partner compares you to an ex."
"Your partner calls you by her ex-boyfriend's name."
"Your partner discusses past relationships with unnecessary detail."
"Your partner tells you she considered marrying her last boyfriend."

3. Final set of 24 jealousy-inducing exemplars, men's version.

A You say "I love you" and your partner does not respond
B Your partner cancels a date with you to spend time with another man
C You find out from a friend that your partner had dinner with an ex-boyfriend
D Your partner starts loaning her favorite books and music to another man
E Your partner talks about casual flings she has had with men she didn't know
F Your partner remembers ex-boyfriends' birthdays but always forgets yours
G Your partner says she would rather be in a relationship with someone else
H Your partner has told you she's not certain if she will stay with you or find another partner
I Your partner helped care for another man when he was ill
J Your partner talks about how much she values certain traits in other men; traits she knows that you don't have
K Your partner talks about other men she knows that make her laugh
L Your partner flirts with other men when she thinks you aren't looking
M Your partner obviously enjoyed when another man pursued a relationship with her
N Your partner does not make physical contact with you when there are other men around
O Your partner spends the night at another man's house
P Your partner begins working late nights with a male co-worker
Q Your partner gives another man a very expensive gift for no reason
R Your partner has a very close relationship with another man but won't let you spend time with the two of them
S Your partner gets drunk at a party, leaves for a while and refuses to tell you where she was
T You catch your partner kissing another man
U Your partner tells you she has been having sex with another man
V Your partner initiates physical contact with another man while talking with him
W Your partner mentions an ex-boyfriend and that they had a strong connection
X Your partner dances with another man

4. This study received Human Subjects Board approval from the University of California, Santa Barbara, and all participants provided written consent.

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Supporting Information

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Supporting Information Figure S1.
Supporting Information Figure S2.
Supporting Information Table S1.
Supporting Information Table S2.