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# Functional Variation in Sensitivity to Cues that a Partner is Cheating with a Rival

**Katherine N. Hanson Sobraske · Steven J. C. Gaulin · James S. Boster**

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**Abstract** The costs imposed by a romantic partner's mixed reproductive strategy (MRS) generate selection pressures for anticipatory responses to mitigate or avoid those costs. People will differ in their vulnerability to those costs, based in part on the qualities of their romantic rivals. Thus, we predicted that individuals at high risk of a partner's MRS—women with many sexually accessible rivals and men with many rivals more physically attractive than themselves—would be more attentive to cues that an MRS was being employed than those at lower risk. Based on similarity judgments derived from a successive-pile-sort method, this prediction was supported in a study involving over 1,300 students and community members. These results complement a growing body of research on selection pressures generated by romantic rivals.

**Keywords** Jealousy · Mixed reproductive strategy · Rivals · Romantic threats

## Introduction

Romantic relationships have the potential to enhance or harm reproductive success. In this domain, harmful events can elicit a constellation of plausibly adaptive negative emotions, such as anxiety (Philips, 2010), anger (Buunk & Dijkstra, 2004), disgust (Becker, Sagarin, Guadagno, Millevoi, & Nicastle, 2004), envy (Parrot & Smith, 1993), fear (Sharpsteen, 1991), sadness (Buunk & Dijkstra, 2004), and jealousy (Buss, Larsen, & Semmelroth, 1992). Each of these emotions has a discrete function (cf. Pinker, 1997; Plutchik, 1980; Tooby & Cosmides, 1992): jealousy functions to signal an actual or potential loss to a rival (Clanton & Smith, 1977; Daly, Wilson, & Weghorst, 1982; White & Mullen, 1989). When triggered, jealousy motivates both attention to romantic threats and efforts to mitigate their associated fitness costs (Buss et al., 1992; for a brief review, see Buss & Haselton, 2005). Building on this premise, sex differences in response to relationship threats have become a major focus of research in evolutionary psychology (Buss et al., 1992; Sagarin et al., 2012 and references therein). A variety of between-sex differences are predicted because men and women are differentially vulnerable to particular partner-inflicted fitness costs (e.g., diversion of resources, abandonment, cuckoldry). A substantial literature has explored these predictions (Sagarin et al., 2012; for a between-sex comparison of threats to romantic relationships using the same methods employed here, see Hanson Sobraske, Boster, & Gaulin, 2013).

Despite the rich literature on between-sex differences in jealousy and their plausible basis in sex-specific threats to romantic relationships, comparatively little research has examined parallel within-sex differences (cf. Buss et al., 1992; Murphy, Vallacher, Shackelford, Bjorklund, & Yunger, 2006; Tagler, 2010). Just as differential vulnerability to partner-inflicted fitness costs predicts between-sex differences, it similarly predicts within-sex differences. One important determinant of within-sex vulnerability is variation in the composition of the local mating market: Vulnerability to partner-inflicted fitness costs is higher for individuals surrounded by numerous, desirable romantic rivals (Traes & Giesen, 2000; Zhang, Parish, Huang, & Pan, 2012).

Rivals are desirable if they offer traits sought in a partner—either a long-term partner or a short-term, extra-pair copulation (EPC) partner (cf. Dijkstra & Buunk, 1998). When employed as

K. N. Hanson Sobraske (✉) · S. J. C. Gaulin
Department of Anthropology, University of California, Santa Barbara, Santa Barbara, CA 93106-3210, USA
e-mail: k_n_hanson@umail.ucsb.edu

J. S. Boster
Department of Anthropology, University of Connecticut, Storrs, CT, USA

part of a mixed reproductive strategy (MRS), EPCs can elevate reproductive success relative to what is achievable with only a sole, primary partner. For men, monogamy can hamper reproductive success if mating opportunities are neglected during their partners' infertile periods of gestation and lactation (Clutton-Brock & Vincent, 1991). We do not claim that men are never monogamous or that monogamy cannot lead to considerable reproductive success—nor do we suggest that other evolutionary-minded researchers generally make such claims. However, the biological requirements for reproduction dictate that the average man's reproductive success, like that of other male mammals, is ultimately limited by his sexual access to women (for a thorough discussion, see Andersson, 1994). Therefore, men's MRS entails provisioning the best-available primary partner and her offspring while seeking additional mating opportunities via EPCs (e.g., Davies & Shackelford, 2008; Figueredo & Jacobs, 2000; Gangestad & Simpson, 2000; Gaulin & McBurney, 2001; Shackelford et al., 2004). Such an MRS is potentially costly to his primary partner because she stands to lose some (or all, if he abandons her) of his resources to a rival (Petrie & Hunter, 1993; Scheib, 2001; Trivers, 1972; Westneat, Sherman, & Morton, 1990). A woman is more vulnerable to these costs when there are many sexually-accessible rivals in her local mating market. A sexual accessible rival is tautologically required for an EPC to occur and therefore accessibility is functionally desirable by men seeking an EPC partner (Dijkstra & Buunk, 2002; Schmitt et al., 2004; Schmitt & Buss, 2001; Stillman & Maner, 2009).

Women are burdened with greater minimal parental investment (Trivers, 1972) and thus cannot achieve the same reproductive rate as men. Therefore, a woman's MRS differs from a man's MRS. For women, an MRS entails harvesting both high-quality paternal investment and high-quality genes—but from different males. An individual man is unlikely to provide both the best genes and the best parental investment. Thus, the female MRS typically involves securing the best available investment from a long-term, primary partner and the best available genes from an EPC partner (e.g., Cashdan, 1996; Geary, Vigil, & Byrd-Craven, 2004; Hodges-Simeon, Gaulin, & Puts, 2010; Little, Jones, Penton-Voak, Burt, & Perrett, 2001; Scelza, 2011). A woman's MRS is costly to her cuckolded partner because he expends his resources to advance a rival's genes (Buunk, Angleitner, Oubaid, & Buss, 1996; Goetz & Shackelford, 2009; Voracek, Fisher, & Shackelford, 2009). A man is particularly vulnerable to these costs when the local mating market contains many rivals of relatively higher genetic quality. This is because women's strategy of engaging in an EPC to acquire the best available genes is only adaptive if the EPC partner does, in fact, have better-quality genes than those of her primary partner (e.g., Bellis & Baker, 1990; Buss & Schmitt, 1993; Gangestad & Simpson, 2000; Geary et al., 2004; Little et al., 2001; Pillsworth & Haselton, 2006; Puts, Dawood, & Welling, 2012a; Scheib, 2001).

As outlined above, both men and women can reap fitness benefits by implementing an MRS, but they may also experience fitness costs arising from their primary partner's counter-strategies. Hence, for both sexes, the motivation to engage in an MRS should be calibrated to these costs and benefits and thus is likely to depend on the qualities of potential EPC partners. Thus, a person who perceives the local mating market to include many desirable rivals should be particularly sensitive to cues his or her partner is implementing an MRS so counterstrategies can be deployed to minimize harm. This perspective yields two predictions—one for each sex—about within-sex differences in response to relationship threats:

1. Men who perceive they have many rivals of relatively higher genetic quality will be more sensitive to cues that their partner: (1) is having sex with another man, *and* (2) intends to remain in the primary relationship. We specify *relatively* higher genetic quality because—irrespective of absolute levels—an EPC will only be strategic if the genes acquired are better than those offered by the primary partner.
2. Women who perceive they have many sexually-accessible rivals will be more sensitive to cues their partner is engaging in EPCs. Contrary to men, *absolute*—not relative—degree of rival sexual-accessibility is of concern because men's reproductive success is limited by the number of female sex partners, a factor independent of his primary partner's sexual accessibility.

Testing these predictions requires a method that can unobtrusively track sensitivity to relationship threats and extract beliefs about what these threats signify. Neither the forced-choice methodology (e.g., Buss et al., 1992) nor the rating scales often used in evolutionary research on jealousy (e.g., Cann & Baucom, 2004; Edlund & Sagarin, 2009; Guadagno & Sagarin, 2010) can provide these types of data. Additionally, typical stimuli (e.g., "Imagine your partner enjoying passionate sexual intercourse with that other person") are inappropriate for addressing these predictions as they describe strong, clear threats to fitness and therefore produce little variance in response, regardless of the composition of the local mating market (cf. Schützwohl, 2005; Schützwohl & Koch, 2004). More to the point, a "partner enjoying passionate sexual intercourse with [an]other person" is not a *cue* of an EPC; it is a verification. In short, typical jealousy methods and stimuli are inappropriate for measuring cue sensitivity.

To monitor MRS cue sensitivity, we used a similarity-judgment task and a suite of two dozen relationship threat exemplars. Similarity judgments can be used to reveal the implicit conceptual structure of relationship threats by tracking sensitivity to particular threat exemplars and extracting participants' beliefs about what these exemplars signal in the context of romantic relationships. Comparisons of conceptual structures can then be made within-sex, based on participants' assessments of the composition of the local mating market.

While relatively unexploited in evolutionary research (for an exception, see Singh & Luis, 1995), similarity data have been used to identify the implicit conceptual structure of many different domains. Multidimensional scaling or correspondence analysis (CA) (Greenacre, 1984; Hirschfeld, 1935) are applied to these similarity data to produce graphical representations of the relevant domain's conceptual structure as it is represented in informants' minds (Brewer, 1995; Jaworska & Chupetlovska-Anastasova, 2009; Romney, Moore, & Rusch, 1997; Ryan & Bernard 2003; Torgerson, 1965). Graphical representations of similarity data have been used to study conceptual structures (Boster, Berlin, & O'Neill, 1986; Cliff & Young, 1968; Russell, 1983; Salovey & Rodin, 1986; Weller, 1986) and a variety of perceptual domains (Baumann & Belin, 2010; Boster, 1986; Kay & Regier, 2003; Picard, Dacremont, Valentin, & Giboreau, 2003; Zarzo, 2011). Representations generated by multidimensional scaling or CA "can be used to explore and discover the defining characteristics of unknown social and psychological structures, but also to confirm a priori hypotheses about these structures" (Giguère, 2006, p. 105). These methods are especially well-suited to our present study because they reveal the participants' implicit conceptual structure of threats to romantic relationships in a quantitative way. This quantification then allows statistical comparisons between classes of participants who differ in MRS vulnerability.

## Method

The present study was undertaken in six phases: (1) exemplars of events inducing jealousy were nominated and edited with 24 ultimately selected; (2) informants judged the similarity of the exemplars with the successive pile sort (Boster, 1986, 1994); (3) these same informants also reported their assessments of their mating rivals, used to determine MRS risk; (4) similarity of exemplars was graphically represented both as hierarchical trees and as 3D plots; (5) the three principal dimensions of these plots were ascertained by evaluating with third-party ratings of the exemplars; and 6) the similarity judgments of high- and low-risk subpopulations were compared. This multi-phased approach is typical of studies comparing similarity judgments between two populations (Boster et al., 1986; Cliff & Young, 1968; Weller, 1986).

### Participants

Phase 1 involved nomination of jealousy-inducing exemplars from 632 participants (226 men; age $M = 20.60$ years, SD = 6.07, range 18–47). They were enrolled in an introductory anthropology course and each nominated one jealousy-inducing threat exemplar. These participants were not involved in the rating task or the similarity-judgment task.

Phases 2 and 3 involved similarity judgment task participation and risk assessment from 131 men (age $M = 22.48$ years, SD = 4.66, range 18–42) and 129 women (age $M = 22.27$ years, SD = 4.59, range 18–43). They were either university students who self-enrolled for course credit via an online scheduling system, or near-by community members recruited in person by research assistants; community participants were not compensated. The online scheduling system did not display this study as a participation option for university participants who described themselves as homosexual; when recruiting potential community participants, research assistants described the study as being for "heterosexual non-students between 22 and 45 years of age." Nonetheless, data from eight people describing themselves as mostly- or completely homosexual were acquired. Because we were testing hypotheses about adaptive (evolved, reproductively motivated) mating tactics, which should be most unambiguously expressed in heterosexuals, data from these eight participants were removed prior to analysis. This created a participant pool of 68 university men, 63 community men, 66 university women, and 63 community women, all reporting an exclusively or primarily heterosexual orientation. These 260 participants judged the similarity of jealousy-inducing exemplars and provided information about their local mating rivals used to determine MRS risk class. There were no significant differences in current involvement in an invested, committed relationship between high MRS-risk participants and low MRS-risk participants, either for men ($\chi^2 < 1.00$) or for women ($\chi^2 < 1.00$).

Phase 4 was analytic only and did not require participants. Phase 5 involved ratings of exemplar qualities from 486 people (232 men). Participants rated the jealousy-inducing exemplars on one or two (of six) qualities (see "Dimension description" below). These participants were not involved in the nomination task or similarity judgment task. Phase 6 was analytic only and did not require participants.

### Measures and Procedure

Phase 1 was determining the suite of jealousy-inducing exemplars, the first step of which was generating a free list. Participants were prompted with: "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." Of the 632 nominated jealousy-inducing exemplars, six were exemplars of envy rather than exemplars of jealousy (i.e., no potential romantic loss was mentioned; for example, "My partner saw someone famous on the street"). Because the focus of the study was on jealousy, rather than a wider expanse of relationship problems, these six exemplars were removed. Of the remaining 626 nominations, redundant exemplars were removed (by KNHS), leaving 47 potentially unique candidate exemplars.[1] To further reduce this exemplar set in a principled manner, seven pre-raters not involved in any other part of the study performed similarity judgments on these candidate exemplars. A plot reflecting the conceptual space of the candidate jealousy-inducing exemplars was produced using CA (see below for fuller descriptions of both similarity judgment and graphical representation methodologies). Finally, exemplars were retained as stimuli in the study if they were conceptually unique or if they maintained the full range of the variation (i.e., were on the edge of the data cloud).[2] These final 24 exemplars are listed in the Appendix; many were similar to stimuli in other jealousy studies (Buss et al., 1992; Dijkstra, Barelds, & Groothof, 2010; Hupka et al., 1985; Schützwohl, 2005).

Phase 2 involved conducting similarity judgments among these 24 jealousy-inducing exemplars using the successive pile sort methodology (Boster, 1986, 1994). Successive pile sorts require participants to make hierarchical similarity judgments by sorting the exemplars into groups and then naming the groups with a brief description of its main feature (e.g., "things that don't bother me much"). With this method, each participant's judgment of inter-exemplar similarity and their major unifying themes were simultaneously identified.

Phase 3 was risk class assignment. Participants involved in the similarity judgment task were classified as either high- or low-risk for a partner employing an MRS based on their assessments of mating rivals. First, participants estimated the percentage of same-sex people in their local environment (cf. Zhang et al., 2012) who are of an age to be mating rivals. Participants then rated perceived qualities of these rivals on a 6-point Likert scale. For men, the target quality was physical attractiveness relative to the participant—a commonly-used proxy for genetic quality (Pillsworth & Haselton, 2006; Puts, Welling, Burriss, & Dawood, 2012b; Thornhill & Gangestad, 1993; Zahavi, 1975). For women, the target quality was degree of sexual accessibility. To determine MRS risk, the percentage of local rivals and scores on rivals' target quality were *z*-scored and summed. Using this *z*-score, high- and low-risk classes were assigned by mean split. While a mean split reduces variability, this dichotomization was necessary for the statistical method employed (see within-sex comparisons below). Fifty-six men and 69 women were deemed high-risk.

Phase 4 was the graphical representation of participants' similarity judgments. To do so, participants' similarity judgments were collapsed, both into a total participant population and, separately, into one of four sex-by-risk-class subpopulations. Judgments made by each of these five populations were used to produce both representative dendrograms and 3D plots. The dendrograms were produced using average link hierarchical clustering. For clarity, dendrograms are shown as reduced trees, displaying only the top five splits between the jealousy-inducing exemplars. The 3D plots—created using CA (Greenacre, 1984; Hirschfeld, 1935)—represent the participants' implicit conceptual mapping of exemplars. These *jealousy spaces* were arranged with physical proximity between exemplars reflecting perceived similarity by the participants. The plots' dimensions were ordered by the amount of variance explained: The first dimension (explaining the most variance) is represented by the *x*-axis, the second dimension is represented by the *y*-axis, and so on. Only the first three dimensions were explored in our analyses.

Phase 5 was the ascertainment of the first three dimensions of the jealousy spaces. This was achieved by correlating the exemplars' coordinates in the 3D plots with independent ratings of the exemplars on six qualities using 6-point Likert scales. For example, to characterize the first dimension, we correlated the *x*-coordinates of the 24 exemplars with their Likert ratings on each of six rated qualities (below). In the cases where more than one quality significantly correlated with a particular axis, we evaluated which correlations were stronger and whether there were mediating effects among them.

The six rated qualities were chosen either on the basis of pre-existing theory or empirical examination of the jealousy spaces. Pre-existing theory about the adaptive function of jealousy (see Introduction) suggests that sexual and emotional infidelity pose distinct threats to romantic relationship (Buss et al., 1992; Sagarin et al., 2012). To acknowledge this perspective, exemplars were rated on the degree to which they indicated sexual infidelity and on the degree to which they indicated emotional infidelity and also along a continuum anchored by these two kinds of infidelity. Three additional ratings were elicited, based on inspection of the 3D plots. These qualities were: threat severity, the presence of a specific rival, and deception by the romantic partner. Specific wording of the ratings scales were:

A. Sexual infidelity: "If your partner did this, would it indicate that your partner is having a sexual relationship with someone else?" (anchor 1 = "Definitely no"; anchor 6 = "Definitely yes").
B. Emotional infidelity: "If your partner did this, would it indicate that your partner has a strong emotional bond

[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.

[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: "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." Other exemplars were retained or omitted in a similar fashion.

with someone else?" (anchor 1 = "Definitely no"; anchor 6 = "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?" (anchor 1 = "Exclusively sexual"; anchor 6 = "Exclusively emotional").
D. Threat severity: "If your partner did this, how serious a problem would it be for your relationship?" (anchor 1 = "Not a problem"; anchor 6 = "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?" (anchor 1 = "Generally uncommitted"; anchor 6 = "Interested in particular individual").
F. Deception: "If your partner did this, would you think (s)he was being sneaky or open?" (anchor 1 = "Open and honest"; anchor 6 = "Sneaky and dishonest").

Phase 6 was within-sex comparisons of similarity judgments. Here the contrast was between men (women) at high versus low risk of their partner's MRS. For each sex, we tested for *both* (1) significant similarity and (2) significant difference in the patterns of judged similarity among the 24 relationship threat exemplars using the Quadratic Assignment Program (QAP) (Hubert & Schultz, 1976). Both tests rely on a large set of 24-by-24 exemplar similarity matrices, one for each participant's similarity judgments. Each cell of each matrix contains an integer that represents the judged similarity between those exemplars as indicated by the pile-sort decisions of that participant.

To test for significant *similarities* between subpopulations, the judged similarity matrices from all the participants in the same sex and risk class were averaged, producing a single similarity matrix for each of the four sex-risk classes. Using QAP, the aggregate similarity matrix of high-risk men (women) was compared to the aggregate similarity matrix of low-risk men (women). This addresses the question "Do high- and low-risk men (women) generally agree on the pattern of similarity among these threats to romantic relationships?"

To test for significant *differences* between subpopulations, analysis again began with participants' judged similarity matrices; however, the matrices were further transformed. Here they were inputs to a larger participant-by-participant matrix where the cell entries represented the correlation between the individual similarity matrices of that pair of participants. (For men, this matrix was 131 by 131 and, for women, it was 129 by 129, due to slight differences in the size of the participant pool for each sex.) Again using QAP, this participant-by-participant correlation matrix was compared to a model matrix with zeros corresponding to pairs of participants from different risk classes and ones corresponding to pairs from the same risk class. This analysis addressed the question "Are the differences between high- and low-risk men greater than the differences within high-risk men (and low-risk men)?"

For tests of both significant similarities and differences, QAP comparisons can be evaluated with a $z$-statistic and also with Monte Carlo simulations. QAP $z$-scores reflect agreement between the compared matrices; higher $z$-scores indicate greater agreement. Monte Carlo simulations are a more direct test of significance. These simulations reflect the percentage of times the compared matrices were more similar than a random permutation of the data. Because the two tests were based on different kinds of matrices (see above), when assessing *similarities* between subpopulations, random permutations alter similarity judgments among threat exemplars; when assessing *differences* between subpopulations, random permutations alter whether a pair of participants is from the same risk-class. For a 5 % tolerance of Type I error, the observed data must be more similar than random permutations of the compared matrices 95 % of the time to be deemed significant. One million permutations were used for each test in this study.

We also made qualitative comparisons between the jealousy spaces and dendrograms of high- and low-risk classes. With the jealousy spaces, we contrasted the configuration of exemplars wherein physical proximity of exemplars reflected perceived similarity. In the dendrograms, the configuration reflected major and minor distinctions between exemplars. Thematic analysis of group names provided by participants' was used to identify major qualities assigned to the suite of relationship threats (Lacey & Luff, 2007; Ryan & Bernard, 2003).

## Results

### The Overall Jealousy Space

Considering all participants together, the overall jealousy space was best described by the severity of threat, the presence/absence of a specific rival, and the deceptive/honest nature of the romantic partner's behavior. The first dimension was most strongly correlated with and best described by severity ($r = .93, p < .01$); severity accounted for all the variance between the first dimension and both the sexual ratings ($\beta = .03, p > .10$) and the emotional ratings ($\beta = -.04$, $p > .10$). This severity dimension is represented by the $x$-axis of the overall jealousy space (Fig. 1). The second dimension was marginally correlated with rival specificity ($r = .35$, $p < .10$) and uncorrelated with the other ratings. This is reflected by the $y$-axis of the overall jealousy space. The third dimension was most strongly correlated with and best described by rival specificity ($r = .60$, $p < .01$) and deception ($r = .78, p < .01$) ratings; deception ratings accounted

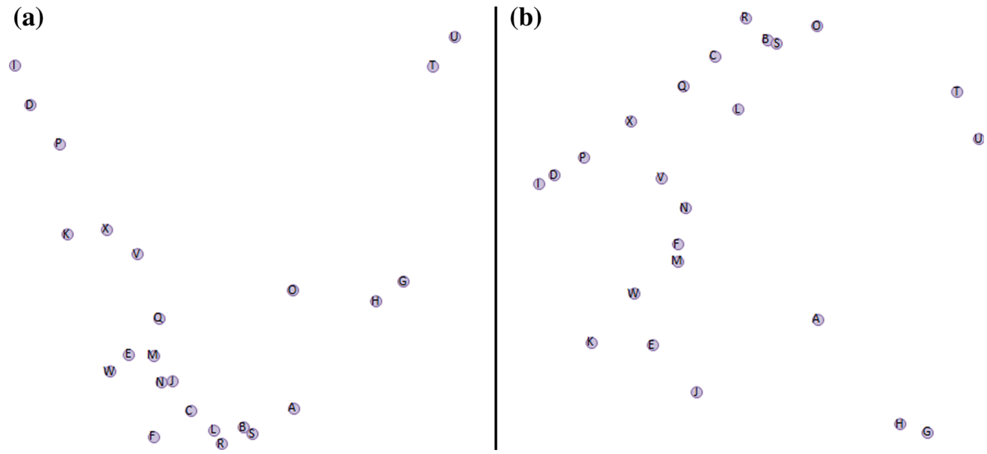


**Fig. 1** Overall jealousy space for all participants: **a** first-by-second dimension, best described by severity of threat (1st) and specificity of rival (2nd); **b** first-by-third dimensions, best described by severity of threat (1st) and both deception by partner and specificity of rival (3rd)

for all variance between the third dimension and sexual-emotional continuum ratings ($\beta = -.12$, $p > .10$). Deception and specificity ratings were not correlated ($r = .22$, $p > .10$).

### High-Risk Men Compared to Low-Risk Men

High-risk and low-risk men's judgments of the jealousy-inducing exemplars were significantly *similar* (QAP $z = 14.29$, $r = .87$, Monte Carlo = 1.00): High- and low-risk men generally agreed on the pattern of judged similarity among these 24 threats to romantic relationships. Agreement was apparent in the equivalent descriptors of high- and low-risk men's jealousy spaces (Table 1; Fig. 2) and in the overlap in group membership in the reduced trees (Fig. 3). However, high-risk and low-risk men's judgments of the jealousy-inducing exemplars were also significantly *different* from each other (QAP $z = 2.09$, $r = .05$, Monte Carlo = .97): The jealousy space was more alike within risk-class than between risk-class. Differences were apparent in the overall shapes and branching structure of the reduced trees (Fig. 3).

For high-risk men, the first dimension of the jealousy space was most strongly correlated with and best described by severity ($r = .94$, $p < .01$); severity ratings accounted for all the variance between the first dimension and both sexual ratings ($\beta = -.05$, $p > .10$) and emotional ratings ($\beta = -.12$, $p > .10$). The second dimension was correlated only with rival specificity ratings ($r = .50$, $p < .05$). The third dimension was most strongly correlated with and best described by deception ($r = .73$, $p < .01$); deception ratings accounted for all variance between the third dimension and the sexual-emotional continuum ratings ($\beta = -.22$, $p > .10$).

For low-risk men, the first dimension was most strongly correlated with and best described by severity ratings ($r = .94$, $p < .01$); severity accounted for all the variance between the first dimension and sexual ratings ($\beta = -.01$, $p > .10$), emotional ratings ($\beta = -.09$, $p > .10$), and sexual-emotional continuum ratings ($\beta = -.04$, $p > .10$). The second dimension was correlated only with rival specificity ($r = .46$, $p < .05$). The third dimension

**Table 1** Dimension descriptors for all four subpopulations

| | Men | | Women | |
|---|---|---|---|---|
| | High-risk | Low-risk | High risk | Low risk |
| First | Severity | Severity | Severity | Severity |
| Second | Specificity | Specificity | Deception | Specificity |
| Third | Deception | Deception | Specificity, sexual-emotional continuum, deception | Deception |

was most strongly correlated with and best described by deception ratings ($r = .75$, $p < .01$); deception ratings accounted for all variance between the third dimension and sexual-emotional continuum ratings ($\beta = -.16$, $p > .10$).

Both high- and low-risk men principally divided exemplars into non-severe threat groups and severe threat groups: exemplars AGH-(O)TU. This division is seen at Split 1 in each reduced tree (Fig. 3). Also, both reduced trees showed a further division of the severe threats into two groups. Thematic analysis of these groups suggests both high- and low-risk men considered these groups to indicate a severe threat to sexual exclusivity—exemplars (O)TU—or a severe threat to emotional exclusivity—exemplars AGH. However, when analyzing only the judgment of severe threats, there were significant differences between high- and low-risk men. The distinction between severe sexual threats and severe emotional threats was more salient for high-risk men, evidenced by the difference in split levels in the reduced trees (Split 2 vs. Split 4); also, high-risk men considered more exemplars severe sexual threats, due to their inclusion of exemplar O with T and U. These structural differences between the severe branches of high- and low-risk men's reduced trees were significant by Fowlkes–Mallows test (for helpful literature on inferential tests of differences in the branching pattern and group membership between comparison dendrograms, see Fowlkes & Mallows, 1983; Nemec & Brinkhurst, 1988). Differences in judgment of the severe threats were also apparent in the group names. When naming the severe emotional threat

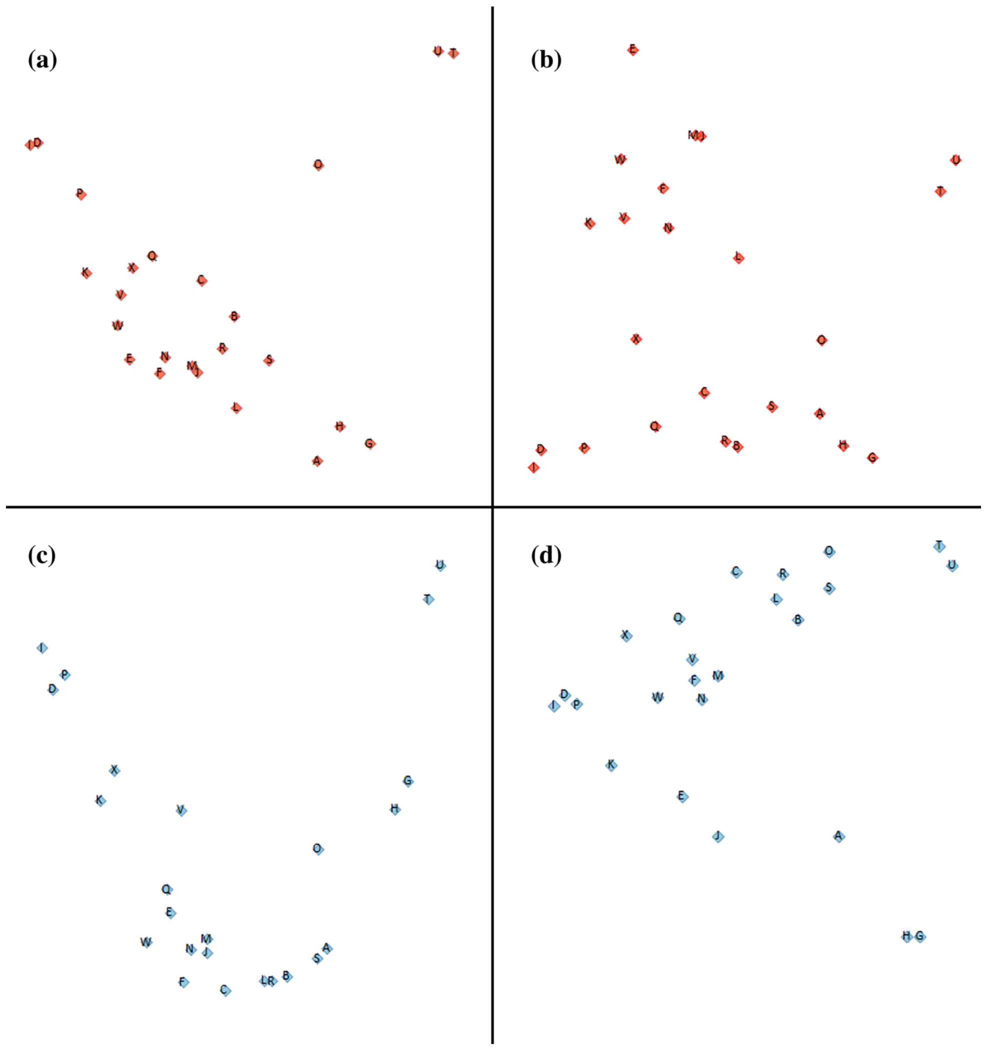


**Fig. 2** High-risk men's jealousy space: **a** first-by-second dimensions, best described by severity of threat (1st) and specificity of rival (2nd); **b** first-by-third dimensions, best described by severity of threat (1st) and deception by partner (3rd). Low-risk men's jealousy space: **c** first-by-second dimensions, best described by severity of threat (1st) and specificity of rival (2nd); **d** first-by-third dimensions, best described by severity of threat (1st) and deception by partner (3rd)

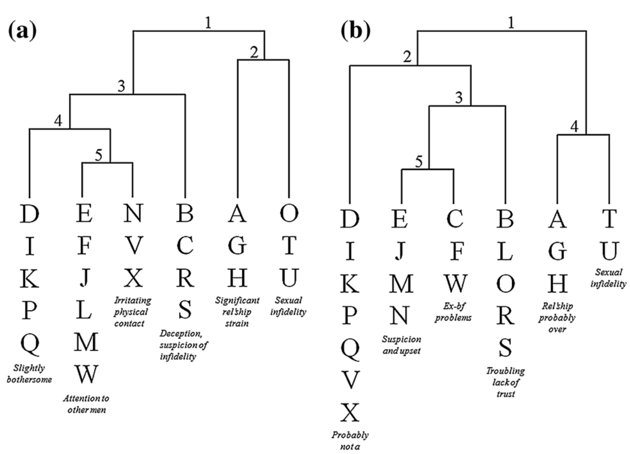


**Fig. 3** Reduced trees for high-risk men (**a**) and low-risk men (**b**) with major group names

group, high-risk men were more likely to state their partner was undecided about maintaining the relationship (e.g., "She is doubting" and "Maybe over") whereas low-risk men assumed she wanted to end it (e.g., "She'll break up with me" and "She doesn't want to stay").

When considering the non-severe exemplars, high-risk men were more attentive to their partners' physical contact with a rival, as evidenced by a separate group, generally named "Physical contact" or "Touching"—exemplars NVX—two of whose members were rated as unimportant by low-risk men.

## High-Risk versus Low-Risk Women

High-risk and low-risk women's judgments of the jealousy-inducing exemplars were significantly *different* from each other (QAP $z = 3.03$, $r = .09$, Monte Carlo = 1.00): The jealousy space was more alike within risk-class than between risk-class. Differences were apparent in the descriptors of each subpopulations' jealousy spaces (Table 1; Fig. 4) and in their reduced trees (Fig. 5). High-risk and low-risk women's judgments of the jealousy-inducing exemplars were also significantly *similar* to each other (QAP $z = 13.62$, $r = .83$, Monte Carlo = 1.00): High- and low-risk women generally agreed on

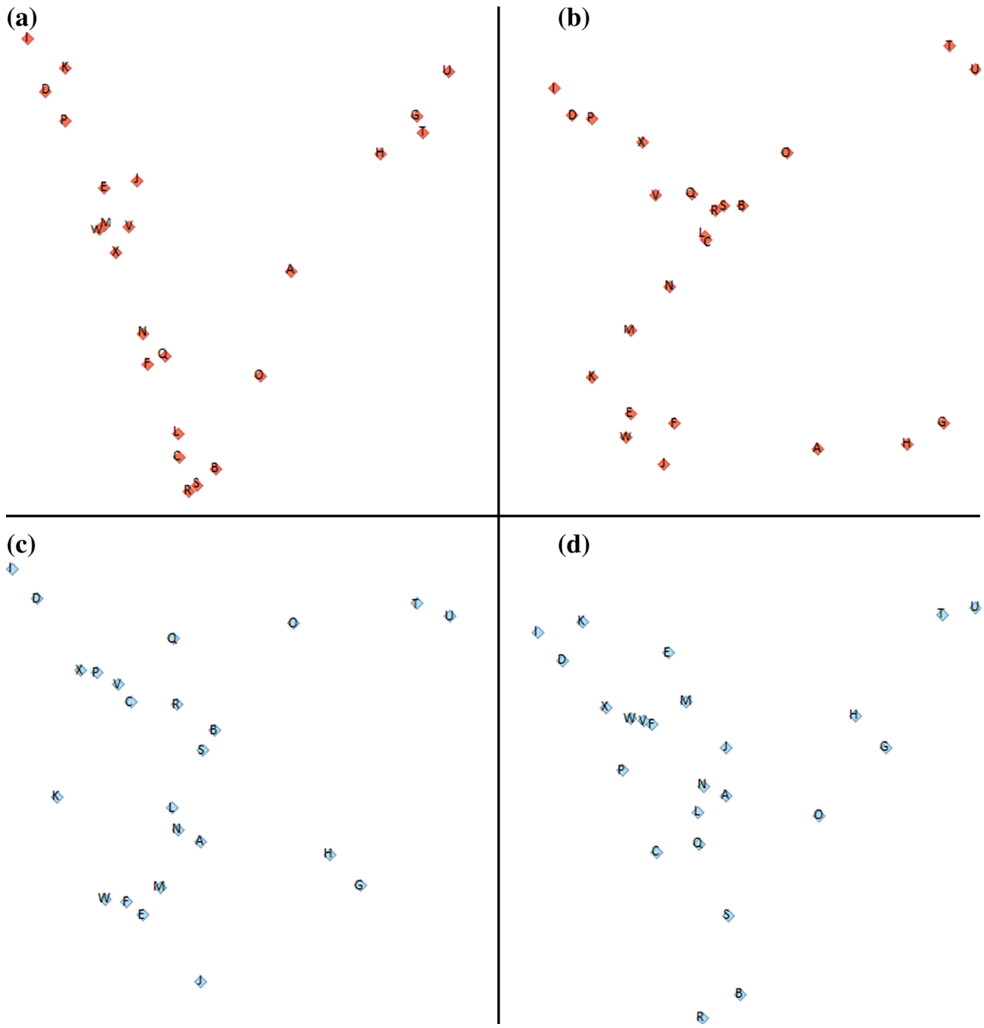


**Fig. 4** High-risk women's jealousy space: **a** first-by-second dimensions, best described by severity of threat (1st) and deception by partner (2nd); **b** first-by-third dimensions, best described by severity of threat (1st) and specificity of rival, sexual-emotional continuum, and deception by partner (3rd). Low-risk women's jealousy space: **c** first-by-second dimensions, best described by severity of threat (1st) and specificity of rival (3rd); **d** first-by-third dimensions, best described by severity of threat (1st) and deception by partner (3rd)

the pattern of judged similarity among these 24 threats to romantic relationships. Agreement was apparent in the overlap in group membership seen in the reduced trees (Fig. 5).

For high-risk women, the first dimension of the jealousy space was most strongly correlated with and best described by severity ($r = .88, p < .01$); severity accounted for all the variance between the first dimension and both the sexual ratings ($\beta = .01, p > .10$) and the emotional ratings ($\beta = .64, p > .10$). The second dimension was correlated only with deception ratings ($r = .70, p < .01$). The third dimension was correlated with rival specificity ($r = .63$, $p < .01$), sexual-emotional continuum ($r = .45$, $p < .05$), and deception ($r = .46, p < .05$); there were no mediating effects.

For low-risk women, the first dimension of the jealousy space was most strongly correlated with and best described by severity ratings ($r = .92, p < .01$); severity accounted for all the variance between the first dimension and sexual ratings ($\beta = .27, p > .10$), emotional ratings ($\beta = -.01$, $p > .10$), and sexual-emotional continuum ratings ($\beta = .04, p > .10$). The second dimension was correlated only with rival specificity ratings ($r = .71$, $p < .01$). The third dimension was correlated only with deception ratings ($r = .55$, $p < .01$). Summaries of dimension descriptors are shown in Table 1; plots are shown in Fig. 4.

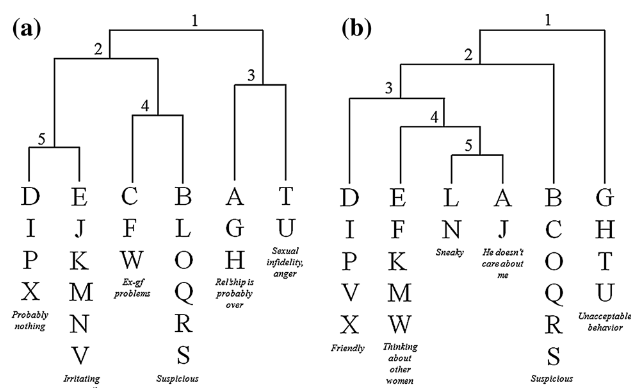


**Fig. 5** Reduced trees for high-risk women (**a**) and low-risk women (**b**) with major group names

Descriptors of the second and third dimensions were "switched" between high- and low-risk women: The position of exemplars along the high-risk second dimension was strongly correlated with the low-risk third dimension ($r = .93$, $p < .01$), and the high-risk third dimension was strongly correlated with the low-risk second dimension ($r = .87$, $p < .01$). This indicates that high-risk women were more attentive to deceptive actions whereas low-risk women were more attentive to the presence of a specific rival.

Both high- and low-risk women principally divided exemplars into non-severe and severe threat groups—exemplars (A)GH-TU—seen at Split 1 in the reduced trees (Fig. 5). However, high-risk women further differentiated severe threats into a severe sexual threat group—exemplars TU—and a severe emotional threat group—exemplars AGH—with group names describing sexual infidelity and a probable cessation of the relationship, respectively (e.g., sexual: "Physical cheating" and "Legit cheating"; cessation: "We would break up, no question" and "End of relationship"). Low-risk women did not make this distinction, considering these exemplars components of a more cohesive group of unacceptable behaviors (e.g., "Deal-breakers" and "Not okay"). This structure of the severe branches of high- and low-risk women's reduced trees was significantly different (Fowlkes & Mallows, 1983; Nemec & Brinkhurst, 1988).

## Discussion

### The Overall Jealousy Space

A large literature suggests that romantic jealousy motivates attention to romantic relationship threats and promotes appropriate counterstrategies. Because men and women face different threats in romantic relationships, this perspective has been usefully invoked to explore and explain between-sex differences in responses to relationship threats (Hanson Sobraske et al., 2013; Sagarin et al., 2012). But vulnerability to particular threats also varies within men and within women, based on their own and their rivals' characteristics. The predicted within-sex variation in response to relationship threats has received relatively little attention.

Using methods designed to unobtrusively map the conceptual structure of jealousy and identify its implicit features, we ascertained the jealousy space—both for a large population of participants and for smaller subpopulations separated by sex and risk of a partner's MRS. The overall jealousy space was best described by severity of threat, rival specificity, and deception by the partner. Each descriptor was consistent with the emotion's adaptive function of motivating and orienting appropriate counter-measures when jealousy is triggered: Threat severity indicated the magnitude of the necessary response; rival specificity targeted the response towards either a weakly-committed partner or towards a particular rival; a partner's deceptive acts motivated greater vigilance regarding the partner's activities. We do not suggest these counter-measures are the only means by which to deal with threats posed by romantic rivals. However, our data suggest that these are the most appropriate means to deal with threats and, further, that the relative appropriateness of each response varied predictably by the composition of the local mating environment.

### Risk of a Partner's MRS Predicts Facultative Shifts in Attention to Relationship Threats

The pile sort method used in this study identified implicit features of threats to romantic relationships and ranked their saliency. Severity, specificity, and deception described the jealousy spaces of men and women at high- and low-risk of a partner MRS. However, the explanatory power of each—as indicated by axis rank—differed between subpopulations, suggesting MRS risk affects judgments of threats to romantic relationships. This notion was further supported by significant differences in the branching structure of the reduced trees and in the names assigned to major exemplar groups. Our data suggest risk of a partner's MRS motivates facultative shifts in attention to particular types of relationship threats, allowing for strategic deployment of adaptive counterstrategies designed to limit costs associated with this MRS. A facultative shift shows economy of design (Williams, 1966): When MRS risk is high, it can promote behavior designed to reduce costs associated with this MRS before it has been employed or, when MRS risk is low, it can decrease costs of unnecessary vigilance. These novel findings were consistent with and advance the existing literature on the adaptive function of jealousy (Sagarin et al., 2012), on the threats rivals pose to romantic relationships (Bleske-Rechek & Buss, 2006; Buss, Shackelford, Choe, Buunk, & Dijkstra, 2000; Buunk & Dijkstra, 2004; Dijkstra & Buunk, 2002; Haselton & Gangestad, 2006; Maner, Miller, Rouby, & Gailliot, 2009; Pillsworth & Haselton, 2006; Schmitt & Buss, 1996), and on facultative shifts in attention to other classes of fitness threats (Barrett, 2005; Lima & Dill, 1990).

### Comparing High- and Low-Risk Men

Overall, men at both high and low risk of a partner's MRS perceived jealousy-inducing exemplars similarly; this was statistically evident by a significant QAP $z$ score and by the Monte Carlo results. The dimensions of the jealousy spaces were described similarly and the major groups of the reduced trees were alike. Overall similarity between men was expected because all men are vulnerable to cuckoldry—albeit to differing degrees.

However, differences were predicted and found between men at high- and low-risk of a partner's MRS. Major differences between high-risk and low-risk men were evident in the reduced trees. Both high- and low-risk men made a primary distinction between non-severe and severe threat exemplars and, further, both high- and low-risk men divided severe threats into severe emotional threats—exemplars AGH—and severe sexual threats—exemplars (O)TU. However, this distinction was significantly more salient for high-risk men, evidenced by its higher position in the reduced tree. This finding was consistent with the prediction that high-risk men were more attentive to cues their partner was having sex with a rival than were low-risk men. Further, the severe sexual threat group of high-risk men was 50 % larger than that of low-risk men, due to the inclusion of exemplar O with exemplars TU. Thematic analysis of the labels assigned to the severe sexual threat groups suggests high-risk men believed exemplar O—along with exemplars TU—indicated a certainty of sexual infidelity whereas low-risk men believed exemplar O—along with exemplars BLRS—demonstrated untrustworthy behavior and suspected sexual infidelity.

Configuration of the reduced trees also revealed high-risk men were more attentive to their partners' non-severe physical contact with rivals than were low-risk men. If physical contact is predictive of later sexual access, this result further supported our prediction that high-risk men, more than low-risk men, will attend to cues their partner is having—or is likely to have—sex with a rival.

Exemplar group labels also suggested high- and low-risk men attended to threats to romantic relationships differently. This was especially apparent in the severe emotional threat group: The names participants provided for this group suggested low-risk men believed their partners would end the primary relationship whereas high-risk men believed their partners were undecided about whether to maintain or end it. In other words, given the same ambiguous relationship threats, low-risk men were more likely to believe these threats implied abandonment by their partner and high-risk men were more likely to believe these threats implied they were vulnerable to cuckoldry. This supports the prediction that high-risk men were more sensitive to cues their partners were employing an MRS.

### Comparing High- and Low-Risk Women

Overall, high- and low-risk women perceived jealousy-inducing exemplars similarly. This similarity was statistically evident by a significant QAP $z$ score and by the Monte Carlo results. It was also graphically evident: Major groups of the reduced trees were significantly similar. As with men, this result was expected: Although we primarily focused on differential vulnerability, all women were vulnerable to resource loss.

While similarities were expected, we also predicted and found differences between women, based on their risk of incurring costs associated with their partners' MRS. We predicted high-risk women—more so than low-risk women—would attend to cues their partners were having sex with a rival. This was supported by the configuration of the reduced trees. High-risk women split the severe threats into separate sexual and emotional threat groups, providing names that indicated, respectively, sexual infidelity and a probable dissolution of the relationship. In contrast, low-risk women did not separate the severe threats, considering them a single group of unacceptable behavior. This was consistent with the prediction that high-risk women were more sensitive to cues of a partner's sexual infidelity than are low-risk women.

The prediction that high-risk women would attend to cues their partner was employing an MRS was further supported by the jealousy spaces. When considering threats to romantic relationships, both high and low-risk women attended to threat severity, rival specificity, and deception by their partner; however, the weight placed on these qualities differed. High-risk women attended more to deception by their partner than to the presence of a specific rival. This supported the prediction that women at high risk of their partners' MRS should preferentially attend to cues he is trying to covertly acquire or hide EPC partners. Low-risk women attended to the presence of a particular rival more than to the deceptive nature of their partners' actions. This suggests low-risk women consider mate switching to be a greater threat to the relationship than is an EPC (cf. Davies, Shackelford, & Hass, 2007; Schmitt et al., 2004; Schmitt & Buss, 2001).

### Strengths, Limitations, and Conclusions

Using a wide range of participant-generated stimuli in a manner relatively free of researcher-imposed constraints, we plotted the jealousy space comprising a suite of threats to romantic relationships. Our method allowed for description of the jealousy space and for hypothesis-testing about its configuration. Using both qualitative and quantitative analysis, data from men and women were consistent with the prediction that greater risk of a partner's MRS would promote increased attention to cues predicting its employment.

The jealousy-inducing exemplars were generated by free-list rather than investigators. This procedure depended on participants' ability to recall or predict circumstances that could elicit jealousy in a romantic relationship and may disproportionately promote particularly salient events. However, we believe this limitation was mitigated by selecting a set of stimuli from candidate exemplars provided by over 600 people and by reducing those candidates to a manageable size that still spanned the jealousy space in an atheoretic manner. Additionally, it is probable that participants' assessments of their position in the mate pool—and hence their vulnerability to a partner's MRS—was imperfect. However, our hypothesis only required that people attend to relationship threats in a fashion consistent with their perceptions of relative vulnerability. Finally, we note that the use of physical attractiveness as a proxy for genetic quality is ultimately a phenotypic gambit (Grafen, 1984); albeit one that is well-supported and widely used (Jennions, Møller, & Petrie, 2001; Petrie & Halliday, 1994; Roberts et al., 2005; Thornhill et al., 2003; for an opposing opinion, see Hadfield, Nutall, Osorio, & Owens, 2007).

In sum, this study presented novel data suggesting that the attention to romantic relationship threats was facultatively dependent on the perceived risk of a partner's MRS. More specifically, men in high-risk environments made stronger distinctions between severe sexual threats and severe emotional threats, suggesting greater attention to cues their partners were having sex with a rival; they were also more likely to attribute ambiguous threats as indicative of their partners' intention to maintain the primary relationship in spite of her perceived infidelity. Similarly, women in high-risk environments were particularly attentive to cues their partners were being deceptive about their interactions with rival women, as would be expected if an EPC was being concealed. These results complement and extend prior research on the selective pressures that romantic rivals generate, supporting the larger notion that human psychology is evolved to attend to fitness threats posed by rivals, and that these adaptations would be most effective if they were appropriately calibrated to relative risks.

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## Appendix

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

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