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Research Report

SEX DIFFERENCES IN JEALOUSY: Evolution, Physiology, and Psychology

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Abstract—*In species with internal female fertilization, males risk both lowered paternity probability and investment in rival gametes if their mates have sexual contact with other males. Females of such species do not risk lowered maternity probability through partner infidelity, but they do risk the diversion of their mates' commitment and resources to rival females. Three studies tested the hypothesis that sex differences in jealousy emerged in humans as solutions to the respective adaptive problems faced by each sex. In Study 1, men and women selected which event would upset them more—a partner's sexual infidelity or emotional infidelity. Study 2 recorded physiological responses (heart rate, electrodermal response, corrugator supercilii contraction) while subjects imagined separately the two types of partner infidelity. Study 3 tested the effect of being in a committed sexual relationship on the activation of jealousy. All studies showed large sex differences, confirming hypothesized sex linkages in jealousy activation.*

In species with internal female fertilization and gestation, features of reproductive biology characteristic of all 4,000 species of mammals, including humans, males face an adaptive problem not confronted by females—uncertainty in their paternity of offspring. Maternity probability in mammals rarely or never deviates from 100%. Compromises in paternity probability come at substantial reproductive cost to the male—the loss of mating effort expended, including time, energy, risk, nuptial gifts, and mating opportunity costs. A cuckolded male also loses the female's parental effort, which becomes channeled to a competitor's gametes. The adaptive problem of paternity uncertainty is exacerbated in species in which males engage in some postzygotic parental investment (Trivers, 1972). Males risk investing re-

sources in putative offspring that are genetically unrelated.

These multiple and severe reproductive costs should have imposed strong selection pressure on males to defend against cuckoldry. Indeed, the literature is replete with examples of evolved anticuckoldry mechanisms in lions (Bertram, 1975), bluebirds (Power, 1975), doves (Erickson & Zenone, 1976), numerous insect species (Thornhill & Alcock, 1983), and nonhuman primates (Hrdy, 1979). Since humans arguably show more paternal investment than any other of the 200 species of primates (Alexander & Noonan, 1979), this selection pressure should have operated especially intensely on human males. Symons (1979); Daly, Wilson, and Weghorst (1982); and Wilson and Daly (in press) have hypothesized that male sexual jealousy evolved as a solution to this adaptive problem (but see Hupka, 1991, for an alternative view). Men who were indifferent to sexual contact between their mates and other men presumably experienced lower paternity certainty, greater investment in competitors' gametes, and lower reproductive success than did men who were motivated to attend to cues of infidelity and to act on those cues to increase paternity probability.

Although females do not risk maternity uncertainty, in species with biparental care they do risk the potential loss of time, resources, and commitment from a male if he deserts or channels investment to alternative mates (Buss, 1988; Thornhill & Alcock, 1983; Trivers, 1972). The redirection of a mate's investment to another female and her offspring is reproductively costly for a female, especially in environments where offspring suffer in survival and reproductive currencies without investment from both parents.

In human evolutionary history, there were likely to have been at least two situations in which a woman risked losing a man's investment. First, in a monoga-

mous marriage, a woman risked having her mate invest in an alternative woman with whom he was having an affair (partial loss of investment) or risked his departure for an alternative woman (large or total loss of investment). Second, in polygynous marriages, a woman was at risk of having her mate invest to a larger degree in other wives and their offspring at the expense of his investment in her and her offspring. Following Buss (1988) and Mellon (1981), we hypothesize that cues to the development of a deep emotional attachment have been reliable leading indicators to women of potential reduction or loss of their mate's investment.

Jealousy is defined as an emotional "state that is aroused by a perceived threat to a valued relationship or position and motivates behavior aimed at countering the threat. Jealousy is 'sexual' if the valued relationship is sexual" (Daly et al., 1982, p. 11; see also Salovey, 1991; White & Mullen, 1989). It is reasonable to hypothesize that jealousy involves physiological reactions (autonomic arousal) to perceived threat and motivated action to reduce the threat, although this hypothesis has not been examined. Following Symons (1979) and Daly et al. (1982), our central hypothesis is that the events that activate jealousy physiologically and psychologically differ for men and women because of the different adaptive problems they have faced over human evolutionary history in mating contexts. Both sexes are hypothesized to be distressed over both sexual and emotional infidelity, and previous findings bear this out (Buss, 1989). However, these two kinds of infidelity should be weighted differently by men and women. Despite the importance of these hypothesized sex differences, no systematic scientific work has been directed toward verifying or falsifying their existence (but for suggestive data, see Francis, 1977; Teismann & Mosher, 1978; White & Mullen, 1989).

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STUDY 1: SUBJECTIVE DISTRESS OVER A PARTNER'S EXTERNAL INVOLVEMENT

This study was designed to test the hypothesis that men and women differ in which form of infidelity—sexual versus emotional—triggers more upset and subjective distress, following the adaptive logic just described.

Method

After reporting age and sex, subjects ($N = 202$ undergraduate students) were presented with the following dilemma:

Please think of a serious committed romantic relationship that you have had in the past, that you currently have, or that you would like to have. Imagine that you discover that the person with whom you've been seriously involved became interested in someone else. What would distress or upset you more (*please circle only one*):

(A) Imagining your partner forming a deep emotional attachment to that person.

(B) Imagining your partner enjoying passionate sexual intercourse with that other person.

Subjects completed additional questions, and then encountered the next dilemma, with the same instructional set, but followed by a different, but parallel, choice:

(A) Imagining your partner trying different sexual positions with that other person.

(B) Imagining your partner falling in love with that other person.

Results

Shown in Figure 1 (upper panel) are the percentages of men and women reporting more distress in response to sexual infidelity than emotional infidelity. The first empirical probe, contrasting distress over a partner's sexual involvement with distress over a partner's deep emotional attachment, yielded a large and highly significant sex difference ($\chi^2 = 47.56, df = 3, p < .001$). Fully 60% of the male sample reported greater distress over their partner's potential sexual infidelity; in contrast, only 17% of the female sample chose that option, with 83% reporting that they would experience

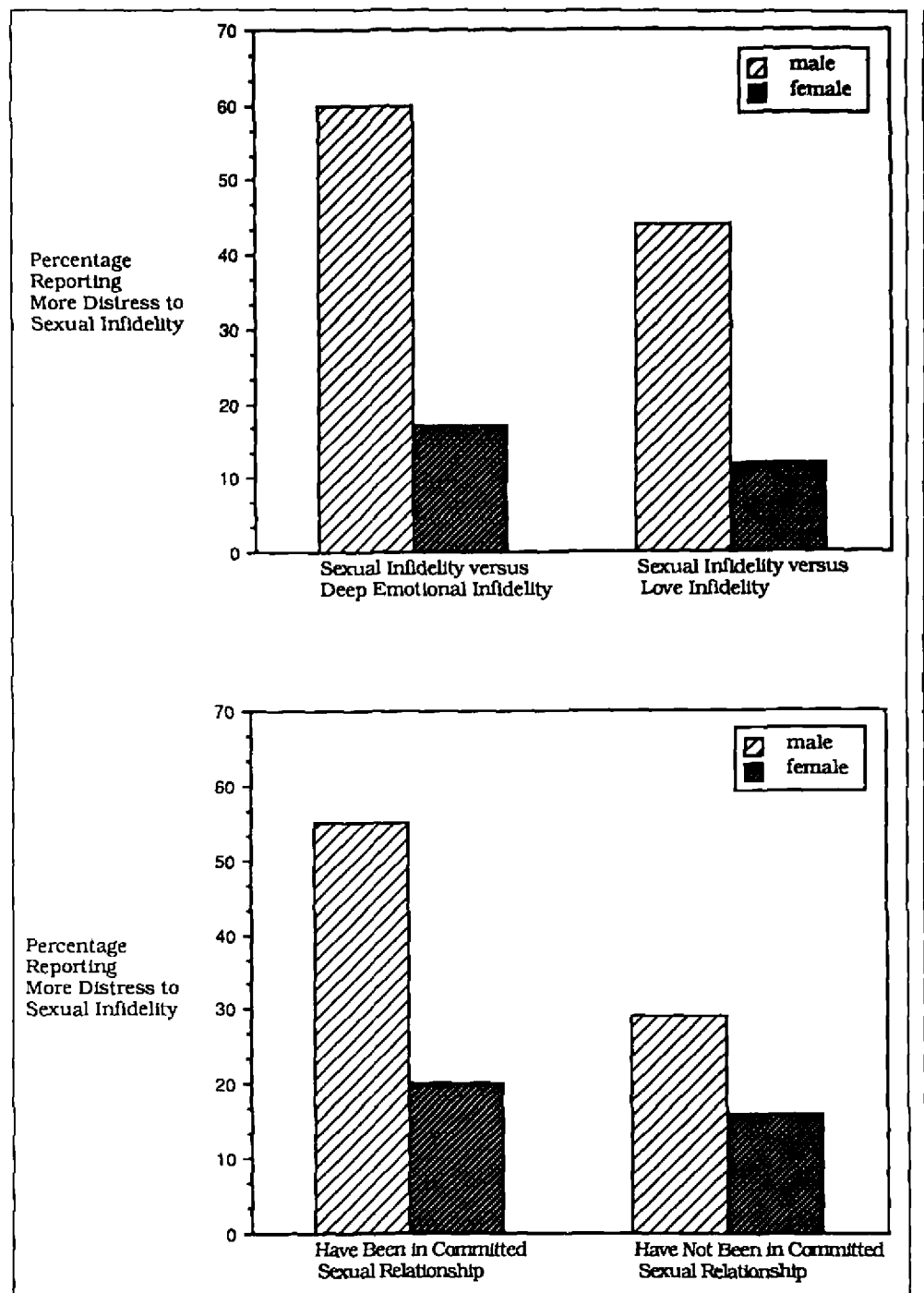


Fig. 1. Reported comparisons of distress in response to imagining a partner's sexual or emotional infidelity. The upper panel shows results of Study 1—the percentage of subjects reporting more distress to the sexual infidelity scenario than to the emotional infidelity (left) and the love infidelity (right) scenarios. The lower panel shows the results of Study 3—the percentage of subjects reporting more distress to the sexual infidelity scenario than to the emotional infidelity scenario, presented separately for those who have experienced a committed sexual relationship (left) and those who have not experienced a committed sexual relationship (right).

greater distress over a partner's emotional attachment to a rival.

This pattern was replicated with the contrast between sex and love. The magnitude of the sex difference was large,

with 32% more men than women reporting greater distress over a partner's sexual involvement with someone else, and the majority of women reporting greater distress over a partner's falling in love

with a rival ($\chi^2 = 59.20, df = 3, p < .001$).

STUDY 2: PHYSIOLOGICAL RESPONSES TO A PARTNER'S EXTERNAL INVOLVEMENT

Given the strong confirmation of jealousy sex linkage from Study 1, we sought next to test the hypotheses using physiological measures. Our central measures of autonomic arousal were electrodermal activity (EDA), assessed via skin conductance, and pulse rate (PR). Electrodermal activity and pulse rate are indicators of autonomic nervous system activation (Levenson, 1988). Because distress is an unpleasant subjective state, we also included a measure of muscle activity in the brow region of the face—electromyographic (EMG) activity of the *corrugator supercilii* muscle. This muscle is responsible for the frowning of the brow often seen in facial displays of unpleasant emotion or affect (Fridlund, Ekman, & Oster, 1987). Subjects were asked to image two scenarios in which a partner became involved with someone else—one sexual intercourse scenario and one emotional attachment scenario. Physiological responses were recorded during the imagery trials.

Subjects

Subjects were 55 undergraduate students, 32 males and 23 females, each completing a 2-hr laboratory session.

Physiological Measures

Physiological activity was monitored on the running strip chart of a Grass Model 7D polygraph and digitized on a laboratory computer at a 10-Hz rate, following principles recommended in Cacioppo and Tassinary (1990).

Electrodermal activity

Standard Beckman Ag/AgCl surface electrodes, filled with a .05 molar NaCl solution in a Unibase paste, were placed over the middle segments of the first and third fingers of the right hand. A Wheatstone bridge applied a 0.5-V voltage to one electrode.

Pulse rate

A photoplethysmograph was attached to the subject's right thumb to monitor the pulse wave. The signal from this pulse transducer was fed into a Grass Model 7P4 cardiometer to detect the rising slope of each pulse wave, with the internal circuitry of the Schmitt trigger individually adjusted for each subject to output PR in beats per minute.

Electromyographic activity

Bipolar EMG recordings were obtained over the *corrugator supercilii* muscle. The EMG signal was relayed to a wide-band AC-preamplifier (Grass Model 7P3), where it was band-pass filtered, full-wave rectified, and integrated with a time constant of 0.2 s.

Procedure

After electrode attachment, the subject was made comfortable in a reclining chair and asked to relax. After a 5-min waiting period, the experiment began. The subject was alone in the room during the imagery session, with an intercom on for verbal communication. The instructions for the imagery task were written on a form which the subject was requested to read and follow.

Each subject was instructed to engage in three separate images. The first image was designed to be emotionally neutral: "Imagine a time when you were walking to class, feeling neither good nor bad, just neutral." The subject was instructed to press a button when he or she had the image clearly in mind, and to sustain the image until the experimenter said to stop. The button triggered the computer to begin collecting physiological data for 20 s, after which the experimenter instructed the subject to "stop and relax."

The next two images were infidelity images, one sexual and one emotional. The order of presentation of these two images was counterbalanced. The instructions for sexual jealousy imagery were as follows: "Please think of a serious romantic relationship that you have had in the past, that you currently have, or that you would like to have. Now imagine that the person with whom you're seriously involved becomes interested in someone else. *Imagine you find out that your partner is having sexual*

intercourse with this other person. Try to feel the feelings you would have if this happened to you."

The instructions for emotional infidelity imagery were identical to the above, except the italicized sentence was replaced with "*Imagine that your partner is falling in love and forming an emotional attachment to that person.*" Physiological data were collected for 20 s following the subject's button press indicating that he or she had achieved the image. Subjects were told to "stop and relax" for 30 s between imagery trials.

Results

Physiological scores

The following scores were obtained: (a) the amplitude of the largest EDA response occurring during each 20-s trial; (b) PR in beats per minute averaged over each 20-s trial; and (c) amplitude of EMG activity over the *corrugator supercilii* averaged over each 20-s trial. Difference scores were computed between the neutral imagery trial and the jealousy induction trials. Within-sex *t* tests revealed no effects for order of presentation of the sexual jealousy image, so data were collapsed over this factor.

Jealousy induction effects

Table 1 shows the mean scores for the physiological measures for men and women in each of the two imagery conditions. Differences in physiological responses to the two jealousy images were examined using paired-comparison *t* tests for each sex separately for EDA, PR, and EMG. The men showed significant increases in EDA during the sexual imagery compared with the emotional imagery ($t = 2.00, df = 29, p < .05$). Women showed significantly greater EDA to the emotional infidelity image than to the sexual infidelity image ($t = 2.42, df = 19, p < .05$). A similar pattern was observed with PR. Men showed a substantial increase in PR to both images, but significantly more so in response to the sexual infidelity image ($t = 2.29, df = 31, p < .05$). Women showed elevated PR to both images, but not differentially so. The results of the *corrugator* EMG were similar, although less strong. Men showed greater brow contraction to the sexual infidelity image,

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Table 1. Means and standard deviations on physiological measures during two imagery conditions

Measure	Imagery type	Mean	SD
Males			
EDA	Sexual	1.30	3.64
	Emotional	-0.11	0.76
Pulse rate	Sexual	4.76	7.80
	Emotional	3.00	5.24
Brow EMG	Sexual	6.75	32.96
	Emotional	1.16	6.60
Females			
EDA	Sexual	-0.07	0.49
	Emotional	0.21	0.78
Pulse rate	Sexual	2.25	4.68
	Emotional	2.57	4.37
Brow EMG	Sexual	3.03	8.38
	Emotional	8.12	25.60

Note. Measures are expressed as changes from the neutral image condition. EDA is in microsiemen units, pulse rate is in beats per minute, and EMG is in microvolt units.

and women showed the opposite pattern, although results with this nonautonomic measure did not reach significance ($t = 1.12$, $df = 30$, $p < .14$, for males; $t = -1.24$, $df = 22$, $p < .12$, for females). The elevated EMG contractions for both jealousy induction trials in both sexes support the hypothesis that the affect experienced is negative.

STUDY 3: CONTEXTS THAT ACTIVATE THE JEALOUSY MECHANISM

The goal of Study 3 was to replicate and extend the results of Studies 1 and 2 using a larger sample. Specifically, we sought to examine the effects of having been in a committed sexual relationship versus not having been in such a relationship on the activation of jealousy. We hypothesized that men who had actually experienced a committed sexual relationship would report greater subjective distress in response to the sexual infidelity imagery than would men who had not experienced a high-investing sexual relationship, and that women who had experienced a committed sexual relationship would report greater distress

to the emotional infidelity image than women who had not been in a committed sexual relationship. The rationale was that direct experience of the relevant context during development may be necessary for the activation of the sex-linked weighting of jealousy activation.

Subjects

Subjects for Study 3 were 309 undergraduate students, 133 men and 176 women.

Procedure

Subjects read the following instructions:

Please think of a serious or committed romantic relationship that you have had in the past, that you currently have, or that you would like to have. Imagine that you discover that the person with whom you've been seriously involved became interested in someone else. What would distress or upset you more (please circle only one):

(A) Imagining your partner falling in love and forming a deep emotional attachment to that person.

(B) Imagining your partner having sexual intercourse with that other person.

Alternatives were presented in standard forced-choice format, with the order counterbalanced across subjects. Following their responses, subjects were asked: "Have you ever been in a serious or committed romantic relationship? (yes or no)" and "If yes, was this a sexual relationship? (yes or no)."

Results

The results for the total sample replicate closely the results of Study 1. A much larger proportion of men (49%) than women (19%) reported that they would be more distressed by their partner's sexual involvement with someone else than by their partner's emotional attachment to, or love for, someone else ($\chi^2 = 38.48$, $df = 3$, $p < .001$).

The two pairs of columns in the bottom panel of Figure 1 show the results separately for those subjects who had experienced a committed sexual relationship in the past and those who had not. For women, the difference is small

and not significant: Women reported that they would experience more distress about a partner's emotional infidelity than a partner's sexual infidelity, regardless of whether or not they had experienced a committed sexual relationship ($\chi^2 = 0.80$, $df = 1$, ns).

For men, the difference between those who had been in a sexual relationship and those who had not is large and highly significant. Whereas 55% of the men who had experienced committed sexual relationships reported that they would be more distressed by a partner's sexual than emotional infidelity, this figure drops to 29% for men who had never experienced a committed sexual relationship ($\chi^2 = 12.29$, $df = 1$, $p < .001$). Sexual jealousy in men apparently becomes increasingly activated upon experience of the relevant relationship.

DISCUSSION

The results of the three empirical studies support the hypothesized sex linkages in the activators of jealousy. Study 1 found large sex differences in reports of the subjective distress individuals would experience upon exposure to a partner's sexual infidelity versus emotional infidelity. Study 2 found a sex linkage in autonomic arousal to imagined sexual infidelity versus emotional infidelity; the results were particularly strong for the EDA and PR. Study 3 replicated the large sex differences in reported distress to sexual versus emotional infidelity, and found a strong effect for men of actually having experienced a committed sexual relationship.

These studies are limited in ways that call for additional research. First, they pertain to a single age group and culture. Future studies could explore the degree to which these sex differences transcend different cultures and age groups. Two clear evolutionary psychological predictions are (a) that male sexual jealousy and female commitment jealousy will be greater in cultures where males invest heavily in children, and (b) that male sexual jealousy will diminish as the age of the male's mate increases because her reproductive value decreases. Second, future studies could test the alternative hypotheses that the current findings reflect (a) domain-specific psychological

adaptations to cuckoldry versus potential investment loss or (b) a more domain-general mechanism such that any thoughts of sex are more interesting, arousing, and perhaps disturbing to men whereas any thoughts of love are more interesting, arousing, and perhaps disturbing to women, and hence that such responses are not specific to jealousy or infidelity. Third, emotional and sexual infidelity are clearly correlated, albeit imperfectly, and a sizable percentage of men in Studies 1 and 3 reported greater distress to a partner's emotional infidelity. Emotional infidelity may signal sexual infidelity and vice versa, and hence both sexes should become distressed at both forms (see Buss, 1989). Future research could profitably explore in greater detail the correlation of these forms of infidelity as well as the sources of within-sex variation. Finally, the intriguing finding that men who have experienced a committed sexual relationship differ dramatically from those who have not, whereas for women such experiences appear to be irrelevant to their selection of emotional infidelity as the more distressing event, should be examined. Why do such ontogenetic experiences matter for men, and why do they appear to be irrelevant for women?

Within the constraints of the current studies, we can conclude that the sex differences found here generalize across both psychological and physiological methods—demonstrating an empirical robustness in the observed effect. The degree to which these sex-linked elicitors correspond to the hypothesized sex-linked adaptive problems lends support to the evolutionary psychological framework from which they were derived. Alternative theoretical frameworks, including those that invoke culture, social construction, deconstruction, arbitrary parental socialization, and structural powerlessness, undoubtedly could be

molded post hoc to fit the findings—something perhaps true of any set of findings. None but the Symons (1979) and Daly et al. (1982) evolutionary psychological frameworks, however, generated the sex-differentiated predictions in advance and on the basis of sound evolutionary reasoning. The recent finding that male sexual jealousy is the leading cause of spouse battering and homicide across cultures worldwide (Daly & Wilson, 1988a, 1988b) offers suggestive evidence that these sex differences have large social import and may be species-wide.

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