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Psychophysiological Responses to Imagined Infidelity: The Specific Innate Modular View of Jealousy Reconsidered

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Three studies measured psychophysiological reactivity (heart rate, blood pressure, and electrodermal activity) while participants imagined a mate's infidelity. The specific innate modular theory of gender differences in jealousy hypothesizes that men are upset by sexual infidelity and women are upset by emotional infidelity, because of having faced different adaptive challenges (cuckoldry and loss of a mate's resources, respectively). This view was not supported. In men, sexual-infidelity imagery elicited greater reactivity than emotional-infidelity imagery. But, sexual imagery elicited greater reactivity even when infidelity was not involved, suggesting that the differential reactivity may not specifically index greater jealousy. In two studies with reasonable power, women did not respond more strongly to emotional infidelity. Moreover, women with committed sexual relationship experience showed reactivity patterns similar to those of men. Hypothetical infidelity self-reports were unrelated to reactivity.

Several evolutionary psychologists have proposed a theory of gender differences in jealousy, which claims that men and women are innately predisposed to react differently to sexual versus emotional infidelity (Buss, Larsen, Westen, & Semmelroth, 1992; Daly & Wilson, 1992; Symons, 1979). These theorists argued that men and women have different innate cognitive or emotional "modules," which determine their reactions to a mate's infidelity. Because fertilization occurs internally within females, paternity is never completely certain. Therefore, a mate's sexual infidelity could lead a male to devote limited resources to raising another's offspring, thus reducing his Darwinian fitness. To forestall this, selective pressures supposedly shaped a specific innate module in men that causes them to be particularly bothered by a mate's sexual infidelity. Women, on the other hand, cannot be tricked into bringing up another's offspring; hence, there is little reason for them to be concerned about their mate's sexual unfaithfulness per se. Instead, women face the risk (to Darwinian fitness) of losing a mate's resources and assistance in raising offspring. It is therefore proposed that selective pressures shaped a specific innate module in women that causes them to be particularly upset by a mate's emotional involvement with a rival. Inherent in this hypothesis is the assumption that a man's emotional involvement is a proxy for his spending resources on another. In sum, male sexual jealousy is seen as a specific mechanism designed by evolution to prevent cuckoldry, whereas female emotional jealousy is seen as a mechanism to prevent resource loss.

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This view of jealousy as a sexually dimorphic adaptation is widely discussed in current editions of social psychology textbooks and has received a great deal of attention in publications written for the general public. In his critically acclaimed book *The Moral Animal,* Robert Wright (1994) cites the jealousy theory as the showcase example of evolutionary psychology—the most rigorously tested hypothesis to emerge from this largely speculative discipline. Pinker's influential book *How the Mind Works* (Pinker, 1997) also cites the analysis of gender differences in jealousy as an especially well-worked-out and rigorously documented contribution to Darwinian psychology. Several papers have presented what would appear to be substantial evidence of gender differences in jealousy elicited by emotional and sexual infidelity. These studies find that the majority of women report that emotional infidelity would be worse than sexual infidelity, whereas men tend to report that sexual infidelity would be worse than emotional infidelity.

The literature in this area sometimes refers to the theory proposed by these evolutionary psychologists as "the evolutionary theory" of jealousy. However, to my knowledge, no researcher in this area disputes the theory of evolution by natural selection. What is at issue is whether evolution in fact shaped the sort of highly domain-specific psychological mechanisms for jealousy proposed by the theorists cited above. A basic premise of much contemporary evolutionary psychology is that the human mind is made of many different, distinct domain-specific psychological mechanisms. However, natural selection also could have created innate psychological tendencies and structures as general as the mechanisms envisioned by social learning theory. Various intermediate levels of specificity, as well as a combination of general and specific mechanisms, are also consistent with Darwinian principles (see Kenrick, Sadalla, & Keefe, 1998). Therefore, the account described above is better termed the hypothesis of *jealousy as a specific innate module* (JSIM).

Summary of Evidence for Gender Differences in Jealousy

The main body of evidence to support gender differences in response to infidelity comes from self-report studies primarily with

college students. In a typical study, men and women are asked to imagine a committed sexual relationship that they have had or would like to have. Participants then choose which form of infidelity would be most upsetting: their mate (a) falling in love with someone else or (b) having sexual intercourse with someone else. Almost all of the researchers that have used this forced-choice method have found a significant gender difference (e.g., Bailey, Gaulin, Agyei, & Gladue, 1994; Buss et al., 1992; DeSteno & Salovey, 1996; Harris & Christenfeld, 1996a). In the United States, the clear majority of women report that they would be more bothered by emotional infidelity, ranging from approximately 62% (DeSteno & Salovey, 1996) to 86% (Buss et al., 1992). However, at most only a slight majority of men say they would be more bothered by sexual infidelity, ranging from 47% (Harris & Christenfeld, 1996a) to 60% (Buss et al., 1992). Using slightly different questions, Wiederman and Allgeier (1993) also found gender differences.

However, it should be noted that not all self-report studies have supported the JSIM view. Gender differences frequently are not found when participants use continuous ratings scales to estimate how upset they would expect to be over each form of infidelity (DeSteno & Salovey, 1996; Harris, 2000b). Also, in two studies, more women than men predicted that they would verbally or physically aggress against a rival or a mate in response to sexual betrayal (de Weerth & Kalma, 1993; Paul & Galloway, 1994). Moreover, in two studies with reasonable power, male and female college students who had experienced a mate's infidelity did not significantly differ in their assessment of how damaging sexual infidelity was to their primary relationship (Hansen, 1987) or in their amount of focus on the sexual and emotional aspects of the infidelity (Harris, 2000b).

A particularly influential and widely cited study examined physiological rather than subjective measures of emotional reactions. Buss et al. (1992) had U.S. college students imagine both a mate engaging in sexual intercourse with someone else and a mate falling in love with another person, while heart rate (HR), electrodermal activity (EDA), and electromyographic activity of the brow (EMG) were measured. This study has been claimed to provide (Buss, 1995; Pinker, 1997; Wright, 1994) unequivocal support for the JSIM hypothesis: Men showed greater reactivity to the imagined sexual infidelity, whereas women showed greater reactivity to the imagined emotional infidelity.

However, an examination of the data from the original article suggests the results are not quite so clear-cut. Buss et al. (1992) used a series of three *t* tests to analyze the data for each gender separately. Men showed significantly more EDA during the sexual scenario (1.30 microsiemen) than during the emotional scenario (-0.11 microsiemen). Women showed more EDA during the emotional scenario (0.21 microsiemen) than during the sexual scenario (-0.07 microsiemen). Heart rate, measured in beats per minute (bpm), provided mixed results. A significant difference in the predicted direction was found for men (4.76 bpm for sexual vs. 3.00 bpm for emotional scenario) but not for women (2.25 bpm for sexual vs. 2.57 bpm for emotional scenario). Analyses of brow EMG activity did not show significant differences for either gender (although the means were generally in the direction predicted by the JSIM model).

Limitations of the Existing Physiological Data

What should be concluded from the Buss et al. (1992) physiological data? Evidently, men show more physiological reactivity to imagined sexual infidelity than to emotional infidelity. Although there are signs that women show the opposite pattern, the data are weak for a couple of reasons. First, only one out of three physiological measures showed a significant difference. Second, the magnitude of the difference between imagining sexual infidelity and imagining romantic infidelity is much weaker for women than for men. The smaller difference scores for women do not appear to be due to a ceiling effect; women did not show much autonomic reactivity while imaging either infidelity scene. For example, women showed less heart rate response to the emotional infidelity scenario than did men. From the standpoint of JSIM, the tenuous differences in physiological reactivity of women to the two forms of infidelity are puzzling, given the self-report data presented by several researchers (Buss et al., 1992; DeSteno & Salovey, 1996; Harris & Christenfeld, 1996a). This issue will be further addressed in the General Discussion.

Differential Reactivity and Emotional States

A key assumption of Buss and colleagues (Buss et al., 1992) is that the increases in physiological activity were indicative of emotional distress over infidelity. This need not be the case, as EDA and HR show increases across a number of emotional states. A complete review of the evidence that different emotional states are accompanied by distinctive patterns of autonomic reactivity is beyond the scope of this article. However, a few points should be noted. First, studies to date have found only a limited set of autonomic differences among a small set of emotions. Furthermore, these differences are often subtle. For example, fear, anger, and happiness all produce accelerated HR; fear and disgust produce larger EDA increases than does happiness, but these increases have not been distinguished from that of sexual reactivity. (Ax, 1953; Levenson, 1992; Schwartz, Weinberger, & Singer, 1981; Zuckerman, 1971). Second, although Buss et al. wrote about the distress associated with jealousy, there is no consensus on the exact nature of that distress. Jealousy may be a discrete emotion, or a blend of several emotions simultaneously occurring, or a series of different emotions elicited by changing reappraisals over the course of a single jealousy episode (Sharpsteen, 1991). Third, studies that have found evidence for differentiated patterns of reactivity have not included jealousy. Thus, it is not known what the specific autonomic indexes of this emotion might be, if any, or how they would be differentiated from increases seen in other states.

Buss et al. (1992) argued that their participants specifically experienced negative affect because they showed an increase (albeit nonsignificant) in brow EMG. Although brow activity often increases during negative emotional states, more recent psychophysiological research challenges the assumption that this occurs exclusively during distress. Pope and Smith (1994) had participants imagine different affectively charged situations (e.g., a friend's injury). When ratings of several aspects of the situation, including pleasantness or unpleasantness, anticipated effort, and "motivational congruence," were included in the analysis, pleasantness or unpleasantness was found to have no significant asso-

ciation with EMG. Sullivan and Brender (1986) had participants listen to stories featuring sexual or nonsexual content and unpleasant or pleasant affect. Left brow EMG recordings were consistent with additive effects of sexual content and unpleasantness (although the statistical term for this comparison was not provided). In another study (Sinha & Parsons, 1996), brow EMG did not differentiate between an emotional imagery scene of fear or of anger and a nonemotional, physical action scene.

The Present Research

The present article explores an alternative account for the Buss et al. (1992) physiological data: The difference in men's reactivity to sexual and emotional infidelity may not reflect different levels of distress but rather some other internal state. One possibility is that men are more reactive to any form of sexual stimuli than they are to emotional stimuli or are more interested in, or better able to, imagine such stimuli.[1] Likewise, the (limited) tendency for women to show differential reactivity to the two types of infidelity may reflect their greater interest in emotional subject matter or their greater ease at imagining emotional stimuli compared with sexual stimuli. These differences might in turn reflect differences in how often men and women have been exposed to pornographic materials (Symons, 1979) or differences in time spent imagining erotic versus romantic situations (Knoth, Boyd, & Singer, 1988). To explore these issues, the present investigation consists of three studies guided by the following objectives.

The first objective was to attempt to replicate the findings of Buss et al. (1992). Replication seems particularly important given that, although the study is frequently cited as providing strong support for the JSIM hypothesis, two of the three measures used by Buss et al. failed to show a significant effect in women's reactions to infidelity, and one out of the three measures used with men failed to reach significance. This could be due to low power in the Buss et al. study, which had 55 participants. To increase power, a total of 207 participants were recruited for the current investigation. The present studies also added measures of systolic and diastolic blood pressure, which are frequently used in psychophysiological studies of emotion but were not used in the Buss et al. study. Given that the HR data for females were not significant, blood pressure provides useful information, because some individuals respond to stressors with an increase in blood pressure without comparable increases in cardiac reactivity (Turner, 1994). As in the Buss et al. study, HR was measured in all the present studies and EDA was assessed in two studies (it was not available for the first study).[2] The second objective was to test the more parsimonious alternative hypotheses alluded to earlier. This possibility was acknowledged by Buss et al., who noted that their results with men could be accounted for by "a more domain-general mechanism such that any thoughts of sex are more interesting, arousing, and perhaps disturbing to men" (p. 255) rather than by a specific adaptation for sexual jealousy. In Study 2, reactivity elicited by infidelity imagery was compared with that elicited by sexual and emotional imagery that did not involve infidelity. The final objective was to explore the relationship of physiological measures to self-report measures and to participants' committed sexual relationship experience, which has not been examined in previous research.

Study 1

In Study 1, I sought to replicate the finding by Buss et al. (1992) that men show greater physiological reactivity to imagined sexual infidelity versus emotional infidelity and to determine if women do indeed show the opposite pattern. Because of resource limitations, the male and female participants were run during different academic quarters, but for ease of presentation, data from both are described here. Statistical analyses are done separately for each gender (as performed by Buss et al.).

Method

Participants. Forty-three women and 36 men participated in exchange for partial fulfillment of course credit for a psychology course at the University of California, San Diego. Data for one female and two male participants are not included in the analyses because of equipment failure.

Physiological measures and procedure. Systolic blood pressure (SBP), diastolic blood pressure (DBP), and HR were measured using an Ohmeda Finapres 2300 Blood Pressure Monitor. This noninvasive device uses the Penaz method to take beat-to-beat readings by means of a small finger cuff and has been shown to provide good tracking of intraarterial readings (e.g., see Parati, Casadei, Groppelli, DiRienzo, & Mancia, 1989).

Upon arriving at the experiment, the participant signed a consent form that explained that the study was exploring various aspects of relationships, including sexual and emotional issues, and that he or she would be asked to imagine scenarios while physiological measures were taken. The Finapres cuff was placed on the participant's middle finger by the female experimenter. The participant was left alone in the room for the duration of the experiment. Following a 5-min baseline period, the experimenter, using an intercom, instructed the participant to turn over the first sheet of paper and to follow the written instructions. Each scenario's instructions were on a separate page. The first scenario was neutral (walking to class) and was included to give the participants a chance to become familiar with an imagery task before the experimental conditions were administered. Once the participants had the image clearly in mind, they pressed a button that signaled that the imagery had begun. The imagery scene lasted for 1 min and was followed by a 1-min rest period. The same procedure was followed for the next two scenarios. The order of the two infidelity instructions was counterbalanced. The procedures and stimuli used in the present study were identical to those used by Buss et al. (1992), with the exception that their participants imagined each scenario for only 20 s with a 30-s rest period between scenarios.

Experimental conditions. Instructions for imagining the infidelity scenarios were taken from Buss et al. (1992):

> Please think of a serious committed romantic relationship you've had in the past, currently have, or 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]* vs. *[Imagine that your partner is falling in love and forming an emotional attachment to that person.]* Try to feel the feelings you would have if this happened to you. (p. 253)

[1] This greater reactivity might reflect sexual arousal, although that is only one viable possibility. This point will be further explored in the General Discussion.

[2] Because EMG measurement did not show any significant findings in the original Buss et al. (1992) study, it is not used in the present investigation.

Table 1
Means and Standard Deviations of Physiological Changes During the Two Infidelity Imagery Conditions for Male and Female Participants in Study 1

Measure	Sexual imagery		Emotional imagery		Difference in reactivity[a]
	M	*SD*	*M*	*SD*	
Women					
Systolic blood pressure	6.97	7.33	6.18	6.51	0.79
Diastolic blood pressure	2.59	4.63	1.95	4.06	0.64†
Heart rate	0.69	5.10	1.12	4.96	−0.43
Men					
Systolic blood pressure	5.50	8.39	3.22	9.57	2.28*
Diastolic blood pressure	2.22	5.30	1.02	7.12	1.20*
Heart rate	1.40	4.39	0.11	5.27	1.29*

[a] Positive numbers represent greater reactivity during sexual imagery compared with emotional imagery.
† $p = .15$. * $p < .05$.

Results and Discussion

Physiological change scores (reactivity) were computed for each of the infidelity imagery conditions by subtracting the average response level during the baseline period from the average response level during the infidelity imagery condition. Multivariate analysis of variance (MANOVA) did not reveal interactive effects of order with imagery condition for either gender; therefore, data were collapsed across order of presentation (although for both genders, the means hinted that reactivity to sexual-infidelity imagery was stronger when it was imagined first.)

To determine whether the two types of infidelity produced differential reactivity, a separate repeated measures MANOVA was conducted for each gender, examining changes in SBP, DBP, and HR during the two infidelity imagery conditions. Mean change scores are presented in Table 1. For women, the change of the three dependent measures taken as a whole, provided no evidence that the degree of reactivity differed for the two infidelity scenarios: Wilks's $\lambda = 0.91$, approximate $F(3, 39) = 1.23$, *ns*.[3] Individual tests of each physiological measure also did not reveal any significant differences in reactions to the two forms of infidelity. (The only test to begin to approach significance was for DBP, $t[41] = 1.45$, $p = .15$. Inspection of the means reveals that, contrary to predictions of JSIM, sexual infidelity tended to elicit greater reactivity than did emotional infidelity.) The present study had almost twice as many female participants as the study by Buss et al. (1992). However, given the null results, a power analysis was performed using the G*Power program of Erdfelder, Faul, and Buchner (1996). The probability is .938 that each of these individual comparisons would detect an effect of the sort described by Buss et al., with a medium effect size ($d = .5$, following Cohen, 1988) were one to exist; the 95% confidence intervals about the difference scores shown in Table 1 were +/-1.99, 0.89, and 1.42 for SBP, DBP, and HR, respectively.

For men, there was a significant effect of type of infidelity imagery: Wilks's λ (0.75) indicated that the change of the three dependent measures, taken as a whole, was significantly greater during the sexual imagery condition than during the emotional imagery condition, approximate $F(3, 31) = 3.40$, $p < .03$. One-tailed t tests showed this effect to be significant for each of the three measures individually: $t(33) = 2.12$, $p < .02$ for SBP; $t(33) = 1.74$, $p < .05$ for DBP; and $t(33) = 2.30$, $p < .02$ for HR.

No evidence was found in Study 1 to support the JSIM model of female jealousy: The physiological response elicited while imagining emotional infidelity was not significantly greater than that elicited while imagining sexual infidelity. At first blush, these findings may appear at odds with the results presented by Buss et al. (1992).[4] However, as noted above, Buss et al.'s female data showed a weak effect, with only electrodermal activity showing a significant difference. Taken together, the original study and the present findings question whether women do indeed show differential reactivity when imagining the two forms of infidelity.

The present study replicated and extended the original Buss et al. (1992) findings for men: Both SBP and DBP as well as HR showed greater increases while men imagined sexual infidelity than while they imagined emotional infidelity. One interpretation is that these data reflect men's greater distress over sexual infidelity. However, as noted earlier, this is not the only possible interpretation.

Study 2

In Study 2, I explored whether men's greater reactivity during sexual-infidelity imagery is specific to infidelity, by examining whether men show greater reactivity to sexual imagery even when it does not involve infidelity. In the present investigation I used a 2 × 2 mixed design. All participants imagined two scenarios, one involving sexual activity and the other emotional activity. Half of the participants imagined scenarios of a mate engaging in infidelity (the manipulation used in previous research), whereas the other half imagined themselves interacting with their mate in each of the sexual and emotional activities. If the differential reactivity is due to something about sexual imagery per se, participants should show greater reactivity in response to sexual imagery compared with emotional imagery regardless of the infidelity or self context.

[3] Throughout this article, p values greater than .15 will be reported as not significant (*ns*).

[4] Where applicable, t tests on reactivity difference scores for the two infidelity conditions were used to compare results from all of the present studies to those of Buss et al. (1992). No significant differences were found for either gender except where noted in Study 3.

Method

Participants. Eighty-two men participated in exchange for partial fulfillment of course credit for a psychology course at the University of California, San Diego. EDA data from one participant and cardiovascular data from two participants are not included in the analyses because of equipment failure.

Physiological measures and procedure. SBP, DBP, and HR were measured, and change scores calculated, as in Study 1. Change in peak electrodermal activity (EDA) was measured using a constant-voltage device (Bioderm Model 2701). Two silver–silver-chloride electrodes were filled with a sodium-free electrode gel and attached to the first and third fingers of the participant's left hand. A female experimenter conducted the experiment. The procedure was the same as in Study 2, except after completing the imagery portion of the experiment, participants filled out a brief anonymous questionnaire (identified only by participant number). On one question, participants were asked to imagine that a mate was involved with someone else and to choose which of the following would be more upsetting: "Imagining your partner trying different sexual positions with that other person?" or "Imagining your partner falling in love with that other person?" (This question is taken from a nonphysiological study by Buss et al., 1992; their physiological study did not use self-report measures of any kind.)

Experimental conditions. Imagery activity (sexual intercourse vs. falling in love) was a within-subjects factor, with order of presentation counterbalanced across participants. Imagery context (infidelity vs. self) was a between-subjects factor. The infidelity group imagined the same two scenarios used in Study 1. The wording of the self-instructions was identical to that of the infidelity instructions with the major exception that instead of being asked to imagine infidelity, participants were asked the following: "Now imagine that you and your partner are having sexual intercourse" and "Now imagine that you and your partner are falling in love and forming an emotional attachment to one another."

Results and Discussion

An Imagery Activity (sex vs. love, within-subjects) × Imagery Context (infidelity vs. self, between-subjects) × Order (sex first vs. love first, between-subjects) mixed MANOVA was conducted on the change scores of the four physiological measures (EDA, SBP, DBP, and HR). Mean change scores are presented in Table 2. Wilks's λ (0.85) indicated that the change of the four dependent measures, taken as a whole, was significantly greater during the sexual-imagery activity than during the emotional-imagery activity, approximate $F(4, 72) = 3.27, p < .02$. Further one-tailed t tests revealed that this effect was significant for three of the measures individually, for SBP, $t(75) = 2.50$, $p < .01$; for DBP, $t(75) = 2.26$, $p < .02$; and for HR, $t(75) = 2.62$, $p < .01$; and marginally significant for EDA, $t(75) = 1.56$, $p = .06$.

There was no hint that the imagery context (infidelity vs. self) produced differential degrees of reactivity on the four physiological measures taken as a whole, Wilks's $\lambda = 0.98$, approximate $F(4, 72) = 0.37$, *ns*, nor did any of the individual tests reveal any significant differences in imagery context. (A medium-size effect would be revealed with probability of .98.)

There was no evidence that the effect of imagery activity interacted with imagery context, Wilks's $\lambda = 0.92$, approximate $F(4, 72) = 1.49$, *ns*, on the four physiological measures taken as a whole, nor did any individual tests suggest an interaction. (A medium-size effect would be revealed with probability of .93.) Imagining sexual activity appears to be more arousing than imagining emotional activity, regardless of whether these male participants were imagining their mates with someone else or with themselves.

The only MANOVA term that revealed an order effect was the Order × Imagery Activity interaction, Wilks's $\lambda = 0.70$, approximate $F(4, 72) = 7.90$, $p < .01$, for the four physiological measures as a whole. Further univariate F tests found that this effect was significant for SBP, $F(1,75) = 4.16$, $p < .05$, and EDA, $F(1,75) = 14.12$, $p < .01$, but not for DBP, $F(1,75) = 0.01$, *ns*, or HR, $F(1,75) = 1.09$, *ns*. Inspection of the means reveals that the difference in amount of reactivity produced during the two imag-

Table 2
Means and Standard Deviations of Physiological Changes During Imagery Conditions for Male Participants in Study 2

Measure	Sexual imagery		Emotional imagery		Difference between imagery conditions[a]
	M	*SD*	*M*	*SD*	
Systolic blood pressure (mmHg)					
Infidelity	7.33	10.12	5.36	8.72	1.97
Self	8.84	9.88	7.02	7.82	1.82
Diastolic blood pressure (mmHg)					
Infidelity	3.30	6.95	2.82	4.95	0.48
Self	5.13	5.71	3.60	4.40	1.53
Heart rate (bpm)					
Infidelity	−0.04	4.83	−1.38	4.64	1.34
Self	−0.25	4.91	−0.94	4.52	0.69
Electrodermal activity (μmhos)					
Infidelity	1.25	1.75	1.13	1.54	0.12
Self	1.42	2.07	1.26	1.84	0.16

Note. There was a significant main effect of imagery activity (sexual > emotional), $p < .01$ for systolic blood pressure, $p < .02$ for diastolic blood pressure, $p < .01$ for heart rate, and $p = .06$ for electrodermal activity. There was no evidence for a significant effect of imagery context (infidelity vs. self) or for an interaction between imagery activity and imagery context.

[a] Positive numbers represent greater reactivity during sexual imagery compared with emotional imagery.

ery conditions was greater when sexual imagery was imagined before emotional imagery. Follow-up MANOVAs indicated that sexual imagery reactivity also was significantly greater than emotional imagery reactivity for each of the orders separately. (All further univariate F tests, except DBP, were significant for the sex–love order but did not reach significance for the love–sex order.)

On the forced-choice written question, 45% of the men from the infidelity condition and 47% from the self condition thought sexual infidelity would be more upsetting than emotional infidelity. Correlational analyses were then performed on the forced-choice response and reactivity difference scores (sexual minus emotional imagery) for each physiological measure. No significant correlations were detected for the sample as a whole ($.05 < r < .13$) or for the infidelity condition group separately ($-.02 < r < .21$). Hence, choosing sexual infidelity as more upsetting on the forced-choice question does not appear to be associated with greater reactivity to sexual imagery generally or to sexual-infidelity imagery specifically. (A medium-size effect for any individual correlation would be detected with the probability .88 for the sample as a whole and .60 for the infidelity group separately).

The results from Study 2 cast doubt on the claim that a domain-specific sexual jealousy mechanism is responsible for men's greater physiological reactivity during sexual-infidelity imagery than during emotional-infidelity imagery. When men imagine interactions involving themselves and their mates, greater reactivity is elicited by sexual activities than by emotional activities. The magnitude of this difference appears unaffected by imagery context (self vs. infidelity). Thus, the difference in men's physiological reactivity to sexual versus romantic imagery is not specific to imagined infidelity per se. The implications of this finding will be explored in the General Discussion.

Study 3

Study 1 failed to find a significant difference in the reactions of women to the two forms of infidelity. One possible weakness of that study is that EDA was not measured. To address this limitation and to again assess women's reaction to the two forms of infidelity, a third study was conducted. Self-report measures were also included.

Method

Participants. Forty-six women participated in exchange for partial fulfillment of course credit for a psychology course at the University of California, San Diego. Data for one participant are not included because the imagery scenarios were administered in the incorrect order.

Physiological measures and procedures. SBP, DBP, HR, and EDA were assessed as in the previous studies and the same infidelity scenarios were again used as a within-subjects factor. At the end of the imagery portion of the experiment, participants filled out a brief anonymous questionnaire that contained the forced-choice infidelity question and the following question: "How many committed sexual relationships have you had?"[5] One female and one male experimenter conducted the experiment.

Results and Discussion

To determine whether emotional infidelity was significantly more arousing than sexual infidelity, a Type of Infidelity (sex vs. love) × Order (sex first vs. love first) mixed MANOVA was conducted on the change scores of the four physiological measures (SBP, DBP, HR, and EDA). Reactivity during the two infidelity scenarios did not significantly differ for the four dependent measures as a whole, Wilks's $\lambda = 0.92$, approximate $F(4, 40) = 0.82$, *ns*, nor did any of the four individual F tests even approach significance. The means and standard deviations (in parentheses) for the four dependent measures were as follows (sexual vs. emotional infidelity): for SBP, 9.16 (9.30) versus 9.09 (9.41); for DBP, 4.63 (5.17) versus 4.18 (4.79); for HR, 0.66 (4.41) versus 0.03 (4.73); and for EDA, 0.77 (1.06) versus 0.77 (1.23). Again, there was no evidence that women were more reactive to emotional infidelity than to sexual infidelity. (The present EDA results were the only finding to significantly differ across any of the present studies and that of Buss et al., 1992) The present study again doubled the number of participants employed by Buss et al. Power was analyzed as in Study 1 (a medium effect size would be detected with probability .95); confidence intervals on the difference scores are +/-1.64, 0.69,1.09, and 0.18 for SBP, DBP, HR, and EDA, respectively.

There was no significant main effect of order of presentation, Wilks's $\lambda = 0.97$, approximate $F(4, 40) = 0.31$, *ns*, (thus, overall amount of reactivity did not seem to differ for the two groups who had different orders of presentation). However, there was a significant Order × Type of Infidelity interaction for the four physiological measures as a whole, Wilks's $\lambda = 0.68$, approximate $F(4, 40) = 4.69$, $p < .01$. Further univariate F tests revealed that this effect was significant for SBP, $F(1, 43) = 8.82$, $p < .01$, and EDA, $F(1,43) = 6.58$, $p < .02$, and approached significance for HR, $F(1, 43 = 3.58$, $p < .07$, but not for DBP, $F(1, 43) = 1.45$, *ns*. The means reveal that the first infidelity imagery produced greater reactivity than the second, regardless of whether it concerned emotional or sexual betrayal.

On the forced-choice written question, 80% of the women chose emotional infidelity whereas 20% chose sexual infidelity as the worse form of betrayal. Analyses were performed correlating the forced-choice response and differences in relative reactivity during the two infidelity imageries (sexual minus emotional) for each physiological measure. No significant correlations were detected ($-.19 < r < .15$). (A medium-size effect for any individual correlation would have been detected with a probability of .68.)

Buss et al. (1992) hypothesized that experience with a committed sexual relationship should cause women to experience even greater distress to emotional infidelity compared with women without such experience. This was examined in the present study by comparing the difference in reactivity (sexual minus emotional) of women who had committed sexual relationship experience with that of women who had no committed sexual relationship experience. A MANOVA revealed a significant effect on the four dependent measures taken as a whole, Wilks's $\lambda = 0.63$, approximate $F(4, 39) = 5.75$, $p < .001$. Univariate F tests revealed that this effect was significant for two of the measures individually: for SDP, $F(1, 42) = 23.61$, $p < .001$, and for DBP, $F(1, 42) = 5.39$, $p < .03$. Relative reactivity scores are presented in Table 3.

[5] In a nonphysiological study, Buss et al. (1992) used a similar query—that is, participants were asked whether they had ever had a committed relationship and whether that relationship was sexual.

Table 3
Means and Standard Deviations of Differences in Relative Reactivity Elicited During the Two Infidelity Imagery Conditions Displayed by Committed Sexual Relationship Experience for Female Participants in Study 3

Measure	With committed sexual relationship experience[a] (n = 22)		Without committed sexual relationship experience[a] (n = 22)		
	M	*SD*	*M*	*SD*	Difference
Systolic blood pressure	3.31	3.88	−3.24	4.99	6.55**
Diastolic blood pressure	1.14	2.19	−0.38	2.15	1.52*
Heart rate	1.11	3.76	0.05	3.54	1.06
Electrodermal activity	0.02	0.44	−0.04	0.75	0.06

[a] Positive numbers represent greater reactivity during sexual imagery compared with emotional imagery.
* $p < .05$. ** $p < .01$.

Contrary to the Buss et al. prediction, the means reveal that women who had committed sexual relationship experience showed greater reactivity to sexual-infidelity imagery than to emotional-infidelity imagery, whereas women without such experience tended to show the opposite pattern. Perhaps the overall responses of women in our sample differ from those of Buss et al. because of differences in the amount of committed sexual relationship experience between the two samples. However, this is only conjecture because the relationship history of the Buss et al. sample is not known.

General Discussion

This investigation presented three studies that reassessed the physiological evidence for JSIM, which claims that different adaptive problems in our ancestral history caused men and women to possess different specific innate jealousy mechanisms. According to recent overviews (Pinker, 1997; Wright, 1994), the psychophysiological data reported by Buss et al. (1992) offer the most convincing evidence for the contention that greater distress is felt by men over sexual infidelity and by women over emotional infidelity. Using additional physiological measures, Studies 1 and 2 confirmed that men do indeed show significantly more reactivity while imagining sexual infidelity than while imagining emotional infidelity. However, the results of Study 2 indicated that men also show greater cardiovascular and electrodermal responses to sexual imagery even when no infidelity was involved.

Buss et al. (1992) believed that the physiological reactivity measured in their study indicated distress and that differences in degree of reactivity reflect differences in amount of distress experienced. As noted earlier, many emotional and cognitive states besides distress lead to activation of the autonomic nervous system (a point I will return to below). Furthermore, the label *jealousy* may include the experience of any of a variety of different distinct emotions depending on the focus of concern (Hupka, 1984). Even if the reactivity measured in both the Buss et al. study and the present one do reflect distress, this may not indicate that men are innately more upset by sexual infidelity than by emotional infidelity. Both genders could be equally distressed by sexual infidelity, but men may be more successful at imagining sexual infidelity than romantic infidelity. For men, sexual imagery may lend itself more readily to a concrete image, whereas emotional imagery may seem more nebulous. Some studies suggest that men typically have less experience than women with romantic fantasy or daydreaming (e.g., women tend to include more emotional details and men tend to report greater reactivity to sexual fantasy; Byers, Purdon, & Clark, 1998; Ellis & Symons, 1990; Knoth et al., 1988). The finding that women who have had a sexual relationship show greater reactivity to sexual infidelity than to emotional infidelity is consistent with this interpretation (e.g., having experience with sex may enable women to more clearly imagine sexual infidelity). This latter finding is hard to square with the JSIM model, which predicts that relationship experience should help activate the emotional jealousy module and sensitize women to emotional infidelity. One limitation of the distress interpretation is that it does not explain the finding in Study 2 that the differences in reactivity elicited by sexual and emotional imagery were apparently the same for those men who imagined infidelity and those who imagined themselves with their mates.

Another, more parsimonious, explanation for these results is that men's greater physiological reactivity to sexual content in the infidelity scenario has the same cause as their greater reactivity to sexual content in the self scenario. One obvious possibility is that their greater responses to sexual scenarios reflect sexual arousal or interest rather than distress. Men could be equally bothered by both forms of infidelity and yet still show greater reactivity to the sexual infidelity scenario because sexual stimuli of any type produce some sexual arousal. This interpretation might also explain why more sexually experienced women show greater reactivity to sexual infidelity than to emotional infidelity.

At first blush, it may seem implausible that imagining a mate having sex with someone else could elicit any sexual arousal. However, it should be noted that the present study, following Buss et al. (1992), used college-age participants, many of whom probably have limited experience with relationships and infidelity (as confirmed by Study 3). Therefore, it should not be surprising if some participants, perhaps especially men, merely succeeded in imagining a sexual scenario and thus experienced some degree of sexual arousal. Furthermore, men are more likely than women to report being sexually aroused in response to upsetting intrusive sexual thoughts (Byers et al., 1998) and tended to report being "more turned on" by their partner after watching a videoclip of a jealousy evoking scenario with a supposed interloper (Shettel-Neuber, Bryson, & Young, 1978).

Clearly, then, neither the psychophysiological measures used in the present studies nor those of Buss et al. (1992) can distinguish the exact nature of the emotional state experienced by the participants. Heart rate, blood pressure, and electrodermal activity increase in a variety of emotional states including anger, fear, and happiness (Ax, 1953; Levenson, 1992; Schwartz et al., 1981). These increases are not readily differentiated from those seen during sexual arousal (Masters & Johnson, 1966; Fisher & Osofsky, 1968; Romano, 1969, cited in Geer & Head, 1990; Zuckerman, 1971).

These uncertainties notwithstanding, the present data clearly raise the possibility that greater physiological responses of men associated with sexual imagery may not be due to specific mech-

anisms related to jealousy but rather to some more general tendency for men to react more to sexual imagery than romantic imagery. This is consistent with the failure in Study 2 to find any relationship between which form of infidelity was chosen as more upsetting on the forced-choice question and relative degree of reactivity elicited by imagining the two forms of infidelity. Future research might explore the issue of exactly what the reactivity indicates by collecting participants' self-reports regarding their emotional reactions. One difficulty, however, is that participants might be reluctant to report that they found it sexually titillating to imagine their mates engaged in sex with another person.

One might attempt to argue that the inclusive fitness benefits of ensuring paternity by preventing cuckoldry will still occur even if the extra concern of men with sexual infidelity follows indirectly from a greater preoccupation with sex rather than from a "sexual jealousy module." Thus, one might claim such an interpretation is consistent with the JSIM hypothesis. However, this alteration abandons the core of the JSIM hypothesis, namely, that sex differences in jealousy reflect *specific* adaptations governing jealousy per se. The JSIM account claims that selection pressure created a module specifically to trigger sexual jealousy, and thereby prevent cuckoldry. If the view is revised as described above, any sex differences in jealousy would not be due to the two genders having different adaptations specifically for jealousy. Rather, such differences would reflect beneficial effects of other, more general adaptations (such as "Be disturbed when something you value is threatened" and "If male, focus on sex"). These slightly more general mechanisms would presumably have been fashioned by natural selection operating over a broad range of situations, not just in the narrow circumstance of infidelity. Thus, modifying the theory in this fashion would fundamentally change the JSIM hypothesis.[6]

The data from women also raise problems for JSIM. Studies 1 and 3 found no indication that women were more distressed by emotional infidelity; average reactivity in both samples did not even differ in the direction predicted by the innate modular view of jealousy. Moreover, contrary to predictions of Buss et al. (1992), women with sexual relationship experience showed significantly greater reactivity to sexual infidelity than to emotional infidelity. These findings, along with the fact that two of the three measures used in the original study (Buss et al., 1992) failed to find an effect in women, render tenuous the hypothesis that women experience greater distress to imagined emotional infidelity.

In sum, given the results from the present investigation, the physiological evidence for the JSIM theory is weak at best. Men show the predicted effects but also react more strongly to sexual imagery generally. Women's reactions are not the mirror image of men's, contrary to JSIM predictions. Further, women who have sexual relationship experience tend to show reactivity patterns more like men, not less.

Other Weaknesses in Evidence for the Specific Innate Modular Theory of Jealousy

This article has focused on the physiological evidence for the JSIM hypothesis, which now seems rather tenuous. Other findings from the literature on jealousy also suggest that the difference between the two gender's reactions to the two forms of infidelity may not be as great as proponents of the JSIM theory have suggested. First, even studies that find evidence of gender differences do not unequivocally bolster the JSIM analysis.[7] In U.S. samples, men are fairly evenly divided in their predictions over which form of infidelity would be worse (never more than 60% choose sexual infidelity). This is hard to reconcile with the JSIM view. Second, the pattern for the self-report measures does not match the pattern of reactivity measures. Men show markedly greater reactivity when imagining sexual infidelity, but as just noted, in self-reports they appear evenly split in which form of infidelity is chosen as worse. Women as a group show little difference in physiological reactivity but predict, almost unanimously, that emotional infidelity would be the worse form of betrayal. This inconsistency between the self-report measures and the physiological measures (as well as the lack of correlation between the two reported here) questions the robustness of evidence for the specific innate modular view of jealousy. Third, studies of other cultures have disclosed that a majority of men do not choose sexual infidelity as more upsetting. On one question, approximately 75% of Dutch men and 70% of German men chose emotional infidelity as more upsetting than sexual infidelity (Buunk, Angleitner, Oubaid, & Buss, 1996), as did more than 75% of Chinese men (Geary, Rumsey, Bow-Thomas, & Hoard, 1995). These percentages are virtually identical to those found in the reports of American *women*. (See Harris & Christenfeld, 1996b, for further discussion.) Fourth, as reviewed in the introduction, several studies have failed to find the predicted gender differences in distress over the two forms of infidelity, particularly when continuous measures are used (e.g., DeSteno & Salovey, 1996; Harris, 2000b).

In sum, there is little basis for any general claim that women are innately prewired to be particularly concerned with emotional infidelity but not sexual infidelity or for the claim that men have formed a specific adaptation to respond to sexual infidelity. At most, there seems to be a very modest difference, which is apparent only in certain hypothetical self-report measures and demonstrably weaker than cultural differences in terms of effect size. Moreover, any difference that does exist may be better accounted for by more general sex differences than those suggested by the JSIM hypothesis.

Social–Cognitive Approaches to Jealousy

Several theorists, rather than taking a JSIM approach, have suggested that jealousy can arise whenever one perceives that a rival is threatening something of value in the context of a relationship. Most people do not want their mates falling in love with someone else or sleeping with someone else. When confronted with such acts, people make assessments regarding the degree to which the betrayal is threatening, including appraisals of loss of self-esteem and relationship rewards (Parrott, 1991; White, 1981; White & Mullen, 1989). This approach suggests that the same basic process is involved in jealousy that arises not just in sexual relationships but in other interpersonal relationships as well. Jeal-

[6] The present research only bears on whether the genders have specific innate jealousy modules that respond to different types of infidelity; it does not speak to the viability of modular views in general.

[7] Statistics on spousal abuse and homicide are also frequently cited in support of JSIM. The intricacies of these data are beyond the scope of the present article. For a more detailed analysis see Harris (2000a).

ousy may motivate people to keep what they perceive as rightfully theirs, whether it is a mate's love or a parent's attention. According to studies by Salovey and colleagues (Salovey & Rodin, 1984; Salovey & Rothman, 1991), jealousy is particularly likely when domains that are personally important are threatened.

As previously discussed, there is serious doubt as to whether the differences in reactivity elicited by the two forms of infidelity are actually due to differing levels of distress. However, even supposing for the moment that the greater reactivity of men to sexual infidelity partially reflects greater distress, one would still not have to accept the JSIM interpretation.[8] Such an effect could also be accounted for by extension of Salovey and colleagues' (Salovey & Rodin, 1984; Salovey & Rothman, 1991) domain relevance hypothesis, according to which distress over either form of infidelity should be related to how important sexuality or emotional intimacy is to an individual (see also White & Mullen, 1989, for a similar view). If men as a group find sexual aspects of their relationships more important than emotional aspects, then sexual infidelity would lead to greater jealousy because it threatens a domain of particular personal importance.[9] The present finding that men show greater reactivity to sexual imagery would be consistent with this notion. However, if differences in reactivity are due to distress, then the data from women are particularly troublesome for the JSIM account. Across physiological studies, there is little evidence that women as a group are more reactive to emotional infidelity. To the contrary, half the women in Study 3 (those with sexual relationship experience) showed greater reactivity to sexual infidelity than to emotional infidelity. Not only does JSIM fail to account for these findings, but such findings seriously question the assumption that sexual jealousy is a specific adaptation selected to prevent cuckoldry (because women have never faced such a threat). The data from women are more amenable to a social–cognitive perspective, which can account for within gender differences as well. For example, sexual experience may help shape self-concepts that focus on sexuality and may increase the importance one places on sex as a relationship reward (further work might explore how this varies across genders).

In sum, individual differences (and thereby any gender differences) in jealousy may exist partly because the domains that are relevant to self-concept and to relationship rewards, as well as cognitive appraisals of the meaning of the infidelity, vary across individuals. Biological factors may play some role in a full explanation of whatever gender differences might exist in jealousy, but they may have their effects through more circuitous routes (or intermediate mechanisms) than proponents of JSIM envision.

[8] Buss et al. (1992) assumed that participants imagine the two forms of infidelity independently and that the two genders can do this to the same degree. Recent work (DeSteno & Salovey, 1996; Harris & Christenfeld, 1996a) suggests that men and women differ in the degree to which they regard the two as implying one another in actuality, which might affect their ability to imagine them independently. To faithfully replicate the Buss et al. study, I have not changed the instructions, but agree with an anonymous reviewer that this issue deserves further scrutiny (because it too offers an alternative to JSIM).

[9] Such differences could reflect sex hormones effects on prenatal development, socialization differences, or other factors, for example, differential ease of reaching orgasms due to physical differences between men and women. (See Harris & Pashler, 1995, for a discussion of other possibilities.)

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