

Evidence for Conditional Sex Differences in Emotional but Not in Sexual Jealousy at the Automatic Level of Cognitive Processing

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Abstract

The two evolutionary psychological hypotheses that men react more jealous than women to sexual infidelity and women react more jealous than men to emotional infidelity are currently controversial because of apparently inconsistent results. We suggest that these inconsistencies can be resolved when the two hypotheses are evaluated separately and when the underlying cognitive processes are considered. We studied jealousy with forced-choice decisions and emotion ratings in a general population sample of 284 adults aged 20–30 years using six infidelity dilemmas and recordings of reaction times. The sex difference for emotional jealousy existed for decisions under cognitive constraint, was also evident in the decision speed, increased for faster decisions, and was stronger for participants with lower education. No evidence for a sex difference in sexual jealousy was found. Our results support the view of a specific female sensitivity to emotional infidelity that canalizes the development of an adaptive sex difference in emotional jealousy conditional to the sociocultural environment. Copyright © 2007 John Wiley & Sons, Ltd.

Key words: jealousy; sex differences; evolutionary psychology; automatic processes; cognitive load

INTRODUCTION

'Jealousy' is a concept in many cultures that, in its broadest meaning, describes affective responses to a real or imagined situation where a personally highly valued possession is threatened to be lost to someone else (e.g. Brockhaus-Enzyklopädie, 1996; Merriam-Webster's Collegiate Dictionary, 1993). Jealousy can be particularly intense when a committed sexual relationship is threatened by a rival ('romantic jealousy'; White, 1981; White & Mullen, 1989). In recent years, sex differences in romantic jealousy have been hotly debated, arguably because they serve as a prominent testing ground for an

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evolutionary psychological approach to sex differences in social cognition and emotion (recently e.g. Harris, 2003, 2005; Sagarin, 2005).

In a nutshell, the classic evolutionary hypothesis assumes that men and women react differently to sexual and emotional infidelity because these two types of infidelity posed different adaptive problems. Men are expected to be more jealous to sexual infidelity than women in order to minimize investment in genetically unrelated offspring. Women, in contrast, are expected to be more jealous to emotional infidelity than men in order to minimize loss of paternal investment in their offspring. Because these are sex-typical adaptive problems faced by all mammalian species with internal fertilization and biparental care (Trivers, 1972; Buss, 2000; Buss, Larsen, Westen, & Semmelroth, 1992) assumed that humans have evolved psychological mechanisms that sensitise men to cues of their mate's sexual infidelity and women to cues of their mate's emotional infidelity. In line with evolutionary psychology's focus on domain-specific cognitive modules (Barrett, 2006; Buss, 1995; Tooby, Cosmides, & Barrett, 2005), Buss proposed sex-specific cognitive modules that solved these sex-specific adaptive problems (which was called the 'jealousy as a specific 'innate'¹ module hypothesis' by Harris, 2000). It should be noted that this evolutionary account consists of two independently derived hypotheses, one for sexual infidelity and one for emotional infidelity. Thus, none of them, one of them, or both of them may be true.

In contrast, Harris (2000, 2003) proposed a 'social-cognitive theory of jealousy' where jealousy is the result of an evolved, but domain-general appraisal mechanism. She argues that this mechanism is sensitive to all kinds of threats posed by rivals, including for example siblings competing for parental care. According to this model, which builds on earlier work by Salovey and Rodin (1984), White and Mullen (1989) and many others, jealousy is aroused when a rival outdoes someone in domains that are particularly important to the self, including valued relationships. Because both a mate's sexual and emotional infidelity threatens the loss of a valued relationship for both men and women, this theory does not expect universal sex differences in sexual and emotional jealousy. Instead, they may or may not exist, depending on culturally determined gender roles (Wood & Eagly, 2002). In the current article, we will revisit these seemingly contradictory theoretical positions from a cognitive processing perspective.

A CLOSER LOOK AT THE TWO EVOLUTIONARY HYPOTHESES

Early evolutionary discussions of jealousy by Symons (1979) and Daly, Wilson, and Weghorst (1982) were more concerned with men's stronger sexual jealousy than with women's stronger emotional jealousy. Based on more general theorizing by Trivers (1972), a sex difference for emotional jealousy was first stated as a hypothesis by Buss and co-workers in 1992. To test the two evolutionary hypotheses, Buss et al. (1992) and most subsequent studies used a forced-choice paradigm, where participants are confronted with dilemmas that contrast hypothetical situations of sexual and emotional infidelity, and are forced to choose one alternative as more distressing. If men choose sexual infidelity more often than emotional

¹Evolved psychological modules do not need to be—and indeed, are often unlikely to be—innate. It is more likely that developmental preparednesses and constraints are inherited that allow for the reliable development of the human adaptive design in every generation (Ariew, 1996; Barrett, 2006; Cummins et al., 1999, 2003; Tooby et al., 2005). Since innateness is not an assumption of modern evolutionary psychology, we will put it in parentheses when referring to Harris' (2000, 2003) label of the evolutionary jealousy hypothesis.

infidelity, and *vice versa* for women, this result is interpreted as supporting ‘the’ evolutionary hypothesis. Some authors only require a sex by type of infidelity interaction, where men are more likely than women to choose sexual infidelity as the more distressing alternative, even if both sexes choose type of infidelity more often than the other (e.g. Sagarin, 2005). Both are weak tests of the evolutionary hypotheses because they confound sex differences in sexual jealousy with sex differences in emotional jealousy.

Consider the four cases of a sex by type of infidelity interaction depicted in Figure 1. Panel A presents the strongest possible hypothesis that (a) men react more jealous to sexual infidelity than women, (b) women react more jealous to emotional infidelity than men, (c) men react more jealous to sexual infidelity than to emotional infidelity and (d) women react more jealous to emotional infidelity than to sexual infidelity. According to Harris (2005), all four subhypotheses (a)–(d) should be expected from the specific ‘innate’ module perspective of sexual and emotional jealousy, that is, the two sex differences (a) and (b) *and* the two within-sex differences (c) and (d). Because the four subhypotheses (a) to (d) are principally independent from each other, some of them may be true, others may not. Therefore, each subhypothesis has to be backed up by theoretical considerations and empirical data.

From an evolutionary perspective, both (a) and (b) are ultimately expected in mammals with internal fertilization and biparental care, because males, but not females, faced the problem of cuckoldry (Daly et al., 1982; Symons, 1979), and females, but not males, faced the problem of resource withdrawal (Buss et al., 1992; Trivers, 1972). In addition, both sexes are also expected to be sensitive to the other infidelity type (emotional infidelity for

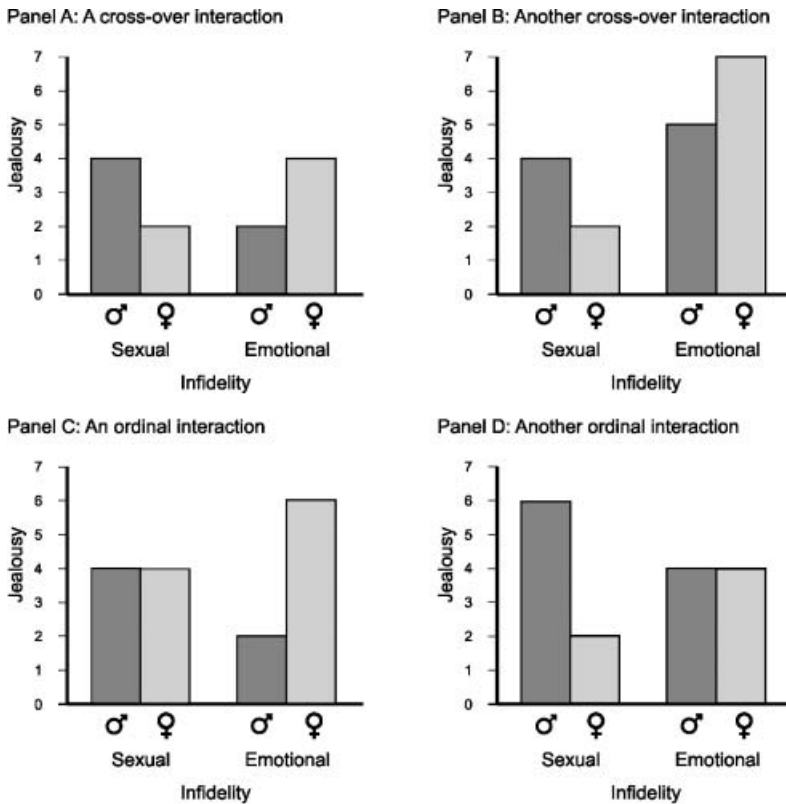


Figure 1. Examples of different kinds of sex \times type of infidelity interactions (see text).

males, sexual infidelity for females) because the loss of a potential mate to a rival is adaptively disadvantageous for both sexes, especially if no alternative mate is at hand (Buss, 1989). Thus, the expected sex differences in sexual and emotional jealousy are a matter of degree, not a matter of yes or no.

In contrast, there are no straightforward evolutionary arguments for the within-sex subhypotheses (c) and (d), because the relative reproductive pay-offs of sexual versus emotional jealousy reactions depend on many more factors than sex. For example, the adaptive value of emotional infidelity varies across environments with the local benefits of parental investments, and with the availability and accessibility of alternative mates. In environments where biparental care is not necessary for successfully raising offspring, or where equally suitable mates are readily available as substitutions, emotional jealousy is a dysfunctional response for both women and men (see Gangestad & Simpson, 2000).

Similarly, the adaptive value of monitoring a mate in order to prevent sexual infidelity depends, among others, on the potential benefits of other activities, like courting other mates, that are missed when spending time and energy securing a mate (Kaplan & Gangestad, 2005), or on the mate's age-related reproductive capacity (Shackelford, Voracek, Schmitt, Buss, Weekes-Shackelford, & Michalski, 2004) and current fertility status (Haselton & Gangestad, 2006; Gangestad, Thornhill, & Garver, 2002). Rigidly reacting with sexual jealousy to cues of sexual infidelity threat might therefore be maladaptive for both sexes under certain circumstances.

In contrast to a full crossover interaction, ordinal interactions violate at least one of the two evolutionary hypotheses. The interaction depicted in Figure 1, Panel C, violates subhypothesis (a) of stronger male sexual jealousy, and the interaction shown in Figure 1, Panel D violates subhypothesis (b) of stronger female emotional jealousy. Note that within the forced-choice paradigm, these cases cannot be distinguished from the crossover interactions depicted in Panels A and B. For example, in the case of Figure 1, Panel C, men would choose sexual infidelity as more distressing than emotional infidelity, although there is no sex difference for sexual infidelity. Thus, the forced-choice paradigm only tests whether one of the two evolutionary hypotheses *or* both hypotheses are supported—it does not test whether *both* hypotheses are confirmed.

The bottom line of our reconstruction is that (1) there are two different evolutionary hypotheses, (2) confirming both requires a crossover sex by type of infidelity interaction, (3) ordinal sex by type of infidelity interactions violate at least one of the two evolutionary hypotheses and (4) sex differences in the forced-choice paradigm may be due to particularly strong male sexual jealousy, to particularly strong female emotional jealousy, or both. Therefore, an evaluation of the two evolutionary hypotheses requires additional tests that evaluate the sex difference for sexual jealousy and the sex difference for emotional jealousy separately.

Whereas the evolutionary approach leads to specific, empirically falsifiable hypotheses, the social-cognitive theory advocated by Harris (2003) does not predict any specific between-sex or within-sex differences in emotional or sexual jealousy. Therefore, it serves as a fallback position for the case that the evolutionary hypotheses (a) and (b) are not empirically supported.

THE NECESSITY TO STUDY COGNITIVE PROCESSES

Beyond functional specialization, evolutionary psychologists make no *a priori* assumptions about the properties or form of implementation of an evolved cognitive module

(Barrett, 2006; Barrett, Frederick, Haselton, & Kurzban, 2006). This point is often misconceived by their critics, which includes DeSteno, Bartlett, Braverman, & Salovey (2002) and their assumption that evolutionary psychologists claim automaticity as a necessary feature of a jealousy module (see Tooby & Cosmides, 2005, footnote 11). However, it is the declared aim of evolutionary psychology to study the design of cognitive modules as the mediating mechanisms between evolution and adaptive behaviour (Cosmides & Tooby, 1987). This requires an integration of the study of ultimate evolved functions and proximate cognitive processes (Maner et al., 2003; Maner, Gailliot, & DeWall, 2007; Maner, Gailliot, Rouby, & Miller, in press). Only if we know, for example, how exactly jealousy modules are implemented into the cognitive system, we will be able to infer how they develop within a certain environmental context, and finally where in the genome their evolved developmental antecedences reside (see already Tinbergen, 1963). It is therefore important to investigate the cognitive processes that underlie emotional and sexual jealousy in more detail.

For example, if participants have no time limits for their decision, they may either respond spontaneously to cues of emotional and sexual infidelity on the basis of automatic tendencies. Alternatively, they may engage in long deliberation, for instance about the details of an infidelity situation ('vivid imagination', which was suggested as necessary by Tooby & Cosmides, 2005, and Barrett et al., 2006), or about the extent to which sexual versus emotional infidelity violates gender roles within their culture (in which case the observed sex differences may solely be driven by compliance with these gender roles). To understand the responses of men and women to jealousy questionnaires, it is necessary to study these cognitive processes in experimental designs.

EMPIRICAL EVIDENCE

Forced-choice paradigm

In a first meta-analysis of sex differences in the forced-choice paradigm based on 32 samples (mainly US undergraduates), Harris (2003) reported a universal sex difference of a moderate effect size for heterosexuals ($d_1 = 0.60$, see Hasselblad & Hedges, 1995; the originally reported log-odds ratio of 1.09 is problematic because large differences are de-emphasized). The sex difference was close to zero in two studies with homosexual participants, and smaller for older adults than for adults of college age. In a more recent meta-analysis based on 72 samples, Hofhansl, Voracek, and Vitouch (2004) reported an average effect size of $d_1 = 0.64$ for heterosexuals, 0.12 for non-heterosexuals, 0.74 for student samples and 0.45 for community samples, with a large variation of the effect sizes across different cultures. Recently, Green and Sabini (2006) confirmed a moderately large sex difference for a representative national sample.

However, the fact that the forced-choice paradigm confounds sex differences in sexual and emotional jealousy prevents strong conclusions, as do two additional methodological problems: First, most forced-choice studies included only one or two dilemmas, most often those introduced by Buss et al. (1992). Therefore, the sex difference may not generalize beyond these two specific dilemmas. Also, the reliability of the individual decisions, and therefore the reliability of the observed sex differences in smaller samples, is rather low.

Second, the classic forced-choice paradigm gives no hint about the cognitive processes that underlie the sex differences in choices. Both automatic and controlled processing is possible.

Separate ratings of sexual and emotional infidelity

An alternative to the forced-choice paradigm is the separate evaluation of sexual and emotional infidelity situations. Its main advantage is that responses to sexual and emotional jealousy are not confounded. A few studies have investigated sex differences in sexual and emotional jealousy with continuous ratings of negative emotional qualities such as jealousy, distress, anger, anxiety and humiliation. By and large, the results failed to confirm the expected sex by type of infidelity interaction (DeSteno et al., 2002, Study 1; Green & Sabini, 2006; Sabini & Green, 2004; Sagarin, 2005), which is inconsistent with the robust sex difference in the forced-choice findings.

Cognitive processing of infidelity cues

Only few studies looked at the cognitive processing of infidelity cues. Schützwohl (2004) measured the reaction time between the presentation of one forced-choice dilemma and the decision in German students. Men choosing sexual infidelity tended to need less time for their decision than women choosing sexual infidelity, and *vice versa* for emotional infidelity. This supports the strong version of the evolutionary hypothesis (see Figure 1, Panel A), although only the sex difference for emotional infidelity was significant (Schützwohl, personal communication, October 2005).

Men choosing sexual infidelity and women choosing emotional infidelity may have been faster because they relied on an initial, automatic response tendency, whereas those selecting the opposite alternative may have engaged in additional reflection upon the alternatives that led them to override their initial response tendencies. It should be noted, however, that even the faster mean reaction times for men and women were above 15 seconds, leaving much room for deliberate reflection in most participants. This may have blurred stronger sex differences at the level of automatic processing.

More informative is a study by Schützwohl (2005), where participants were successively presented with a series of cues to either sexual or emotional infidelity in ascending order of cue diagnosticity. One of the tasks was to determine when they felt jealous for the first time. Men tended to reach the threshold for sexual infidelity faster than women, processing as many cues as women did, and women reached the threshold for emotional infidelity faster than men, again processing as many cues as men did (a crossover interaction as in Figure 1, Panel A). However, again only the sex difference for emotional infidelity was significant (Schützwohl, personal communication, October 2005). The faster processing sex reached the jealousy threshold within 8–9 seconds for both types of infidelity.²

Whereas these two studies by Schützwohl are consistent with the evolutionary hypothesis for emotional (though not for sexual) jealousy, an earlier study by DeSteno et al. (2002, Study 2) dismissed both evolutionary hypotheses. Undergraduates responded to a jealousy dilemma in either a consideration or a cognitive constraint condition. In the consideration condition, the participants were told to consider their responses to each dilemma carefully. Here, 96% of the 25 men and 36% of the 39 women chose sexual infidelity, confirming the expected sex difference. In the cognitive constraint condition, participants were instructed to arrive at their decision within 10 seconds, to simultaneously

²In two other cognitive processing studies by Schützwohl and co-workers, a significant sex difference was also found for sexual infidelity. However, these studies investigated the free retrieval of earlier encoded infidelity cues from memory (Schützwohl & Koch, 2004), and searching strategies for infidelity cues that were not presented (Schützwohl, 2006, Study 1). We consider these studies as only peripheral for our present study, because these sex differences are likely due to information processes that are not guided by actually perceived cues and the immediate affective reactions to them.

remember a seven-digit random number during the decision, and to recall it following the decision. This was a difficult task, because the average reaction time for the standard forced-choice procedure (not reported by the authors for the control group) is at least 15 seconds on average (Schützwohl, 2004; see also our findings below), and because memorizing seven digits over this period constitutes a heavy cognitive load for a choice between two situation descriptions in full sentences, given the average working memory capacity. Nevertheless, 90% of the 63 participants in this condition followed the instruction to choose between sexual and emotional infidelity within 10 seconds. Out of these, 92% of the 26 men chose sexual infidelity, which is not significantly different to the consideration condition. In contrast, 65% of the 31 women chose sexual infidelity, which was significantly more frequent than in the consideration condition. It should be noted, however, that even under cognitive constraint, men chose sexual infidelity significantly more often than women (not reported by the authors; see Sagarin, 2005). Still the authors claimed incorrectly that the sex difference ‘... disappeared under conditions of cognitive constraint’ (DeSteno et al., 2002, p. 1103). This misinterpretation is cited by many, including Harris (2003, p. 117), as evidence that the sex difference in the classic forced-choice paradigm is based on deliberation and not on automatic processing.

Surprisingly, this single study has kindled a heated discussion about the role of automaticity in jealousy and evolved modules (Barrett et al., 2006; DeSteno, Bartlett, & Salovey, 2006; Harris, 2003, 2005; Sagarin, 2005), even though no replication has ever been published. Indeed, a closer inspection of the DeSteno et al. (2002) study reveals two design problems that question its results. First, only one dilemma was used in a small sample of undergraduates, which poses a reliability problem. Second, the order of sexual and emotional infidelity was not counterbalanced; participants may have tended to choose simply the first alternative (which was sexual infidelity) in order to comply with the instruction to respond rapidly. This would explain the more frequent choice of this alternative by the women, which is rather deviant compared to other studies (men’s results were limited by a ceiling effect in the consideration condition). Clearly, more studies using cognitive constraint with larger samples of participants and counterbalanced dilemmas are needed before definitive conclusions on the automaticity of the cognitive processes underlying sex differences in jealousy can be drawn. For now, it must be regarded as an open empirical question.

THE PRESENT STUDY

The aim of the present study was to test the two evolutionary hypotheses with both the forced-choice method and continuous emotion ratings for many different dilemmas in a sample of sexually experienced young adults. To approach the underlying cognitive processes, we studied the automaticity of the responses in the forced-choice task. It was presented in two versions: In the cognitive constraint condition, which was similar to the one used by DeSteno et al. (2002), the participants were instructed to rely on their spontaneous preferences and to simultaneously remember a number that they had to recall after each decision. In the deliberation condition, they were instructed to take their time, to vividly imagine the scenarios and to make careful decisions. We recorded not only the decisions and emotion ratings, but also the response times for each decision and rating. Thus, we were able to evaluate the two evolutionary hypotheses separately with regard to the processing of infidelity cues. Finally, to make a comparison of results for different methods possible within the same sample, we presented the three tasks in the same order for all participants. The order reflected the assumed influence of automatic processes on the

responses: Forced-choice under cognitive constraint (strongest influence), emotion ratings with vivid imagination (intermediate influence), forced-choice with deliberation and vivid imagination (weakest influence).

Based on the review of the literature above, we expected (1) the classic sex difference in the forced-choice paradigm under both conditions, particularly under cognitive constraint, (2) that women rate emotional infidelity situations more negatively than men, but that men do not rate sexual infidelity situations more negatively than women and (3) that women process emotional infidelity cues faster than men, but that men do not process sexual infidelity cues faster than women. In addition, we were interested in the moderating influences of romantic relationship status and education on these effects, because being involved in a relationship may increase the importance of infidelity, and most of the earlier studies used only student samples with questionable generalisability of the results.

METHOD

Sample

German native speakers aged 20 to 30 years were recruited for a study on 'Love, Sexuality, and Personality' in a large city by flyers and postings in various public places (including bars, clubs, concerts, educational institutions, parks, shops, internet cafés and on the streets), as well as by advertisements in a diverse range of media (newspapers, journals, radio stations and the internet). Sixteen euro (approximately 20 dollars) and personal feedback were offered as an incentive for participating in the 2-hour study. The sample was restricted to participants who signed up for the study on the internet, reported a heterosexual orientation, had no children and were currently or had at least once been in a committed, sexual relationship. Participants who were currently in such a relationship were invited together with their partner. A total of 284 participants (71 unmarried couples and 142 singles, 141 men and 143 women, age $M = 23.7$ years, $SD = 2.7$) completed all tasks. Of the participants, 75% had a high-school degree and 60% were students, many of them from non-university institutions. There were no psychology students in the sample.

Design

After completing a reaction time task and answering numerous personality scales as part of a different study, the participants completed three different jealousy tasks in a fixed order: (1) Forced-choice dilemmas with cognitive constraint and the instruction to respond spontaneously, (2) continuous emotion ratings with the instruction to vividly imagine each situation and (3) deliberate forced-choice dilemmas with the instruction to vividly imagine each alternative and to take enough time for the decision. This task sequence was meant to assure that more spontaneous decisions preceded more deliberate ones. Participants were guided through the study by a same-sex experimenter. Couples were simultaneously tested in separate rooms. All assessments were done on computers.

Procedures and measures

Forced-choice with cognitive constraint

Participants were instructed as follows:

'In the following part of the study, we are interested in how you evaluate situations that might occur in a relationship when you are distracted by another task. Therefore, we will

ask you to remember numbers at the same time. Before each trial, we will show you a series of SIX DIGITS. Please try to keep the digits in mind until you are asked to report them! After the six digits, you will see descriptions of two situations that might occur in a relationship. Please think of

- THE RELATIONSHIP WITH YOUR CURRENT PARTNER (*for those in a relationship*)
- A SERIOUS COMMITTED ROMANTIC RELATIONSHIP THAT YOU HAVE HAD IN THE PAST, OR THAT YOU WOULD LIKE TO HAVE (*for singles*).

Please decide SPONTANEOUSLY each time which of the two situations would DISTRESS OR UPSET you more. At the same time, keep the digits in mind! After each decision, please type the series of six digits that you have remembered into the box on the computer screen. There will be 15 decisions altogether. The key requirements for this part of the study are a SPONTANEOUS DECISION and a CORRECT REPRODUCTION OF THE SERIES OF DIGITS'.

After a training item, the participants read 14 different pairs of situations that included six infidelity dilemmas adapted from Buss et al. (1992, 1999) and eight distractors (see Appendix). The order was identical for all participants. Each pair of situations was preceded by a six-digit number that was presented until the participant pressed a button to proceed to the decision task. After the decision and the report of the recalled number, the number of the next trial was shown on the screen. We deviated from DeSteno et al.'s (2002) design by using six-digit numbers instead of the seven-digit numbers and by presenting the number as long as the participant needed to memorize it instead of a fixed interval of 3 seconds. We did this because our general population sample covered a broader range of cognitive ability and a pilot study showed that the original task was judged as extremely difficult by both students and non-students. As in the study by DeSteno et al. (2002), participants received no feedback about the correctness of the reported numbers. We recorded (1) the decision, (2) the reaction time between the presentation of the dilemmas and the participant's decision (which included reading the dilemmas) and (3) the correctness of the remembered number.

Continuous emotion ratings

Participants were instructed as follows:

'Please now report WITHOUT BEING DISTRACTED what you would feel in the following six situations. Please continue to think about

- YOUR RELATIONSHIP WITH YOUR CURRENT PARTNER (*for those in a relationship*)
- A SERIOUS COMMITTED ROMANTIC RELATIONSHIP THAT YOU HAVE HAD IN THE PAST, OR THAT YOU WOULD LIKE TO HAVE (*for singles*).

Please try to imagine the situations VIVIDLY and REALISTICALLY, as well as what you would really feel in the situations'.

Subsequently, the participants rated the six situations for the amount of *anger*, *anxiety*, *jealousy* and *humiliation* (in this order) that they would feel in such a situation, using on 5-point rating scales anchored 'not at all' to 'extremely'. The situations described either an event of emotional or sexual infidelity and were presented in a fixed, alternating order. To

avoid boredom and exhaustion due to 4 (emotions) \times 2 (alternatives) \times 6 (dilemmas) = 48 ratings, each situation description was a combination of two subsequent situation descriptions in the forced-choice tasks. For example, the first sexual infidelity situation was described as follows: ‘... enjoys passionate sexual intercourse with another person and tries different sexual positions with him/her’. Thereby, we created three combined dilemmas and used the six response alternatives from these six dilemmas as the situation. This reduced the total number of ratings to 24 . Recorded were the ratings and the reaction times for each individual rating.

Forced-choice with deliberation

After a short pause, where participants were advised to relax and take a deep breath, participants were instructed as follows:

‘Please continue to think about

- YOUR RELATIONSHIP WITH YOUR CURRENT PARTNER (*for those in a relationship*)
- A SERIOUS COMMITTED ROMANTIC RELATIONSHIP THAT YOU HAVE HAD IN THE PAST, OR THAT YOU WOULD LIKE TO HAVE (*for singles*).

We will once again present you the six pairs of situations, and ask you to choose the one which would DISTRESS or UPSET you more.

Please do now take your time to imagine each situation as VIVIDLY and REALISTICALLY as possible, and take your time for each decision according to your feelings’.

Subsequently, the same six jealousy dilemmas used in the cognitive load condition were presented in the same fixed order as before (see Appendix), but without the distractor items. The decisions and reaction times for each response (which included reading the dilemmas) were recorded.

Educational level

The highest achieved educational level was assessed. On the basis of these ordinal data, we dichotomized the participants into those with lower level (no high-school diploma, 24%) and those with a higher level (high-school diploma, 75%). Three participants could not be classified. We used high-school diploma as the classification variable because it is critical in Germany for getting access to universities and better-paid jobs.

RESULTS

Data recording and screening

The order of sexual versus emotional infidelity within each of the six dilemmas was counterbalanced. The responses were partly recorded such that decisions for sexual infidelity and for emotional infidelity were always coded as 0 and 1, respectively. Inspection of the reaction times revealed a few unrealistically fast responses in the forced-choice condition (i.e. less than 3 seconds for reading the dilemma and making a decision), which were dropped from analysis. Because the reaction times were heavily skewed, log-transformed values were used in all statistical analyses.

Consistency across dilemmas

In the deliberate forced-choice condition, the individual choices were internally consistent across all six dilemmas ($\alpha = .84$). Therefore, they were averaged, forming a reliable preference score ranging from 0 (always choosing sexual infidelity) to 1 (always choosing emotional infidelity). In the forced-choice under cognitive constraint condition, this aggregated preference score was somewhat less reliable ($\alpha = .72$), though the consistency was still sufficient. The lower reliability for the same dilemmas is not surprising, because consistent responses of the participants were compromised by the memory task. Finally, all continuous emotion ratings were consistent across the three sexual infidelity situations and across the three emotional infidelity situations for each emotion. Therefore, they were averaged across the three situations, forming sufficiently reliable scales (mean $\alpha = .77$ for the eight scales).

Similarly, the individual log-transformed reaction times, analyzed separately for sexual infidelity and emotional infidelity choices, formed sufficiently reliable scales when aggregated across the dilemmas for deliberate sexual infidelity choices ($\alpha = .81$), deliberate emotional infidelity choices ($\alpha = .76$), sexual infidelity choices under cognitive constraint ($\alpha = .84$), emotional infidelity choices under cognitive constraint ($\alpha = .81$) and the continuous emotion ratings (mean $\alpha = .64$ for the eight reaction time scales; the lower reliabilities for the rating reaction times seem to be due to the fact that they were aggregated only across three situations). Therefore, only these aggregated score were analyzed.

Forced-choice under cognitive constraint

In this first task, 16% of the participants correctly remembered the six-digit number for all six dilemmas, 61% made two or more errors and two participants always failed to correctly remember the number. The mean error rate was 34.8%. Lower educated participants (those without a high-school degree) did not make significantly more errors than higher educated ones (those with a high-school degree) (38% versus 34%, $t(279) = 1.37$, $p = .18$). Thus, the task was sufficiently difficult to constrain participants' processing capacity, but manageable for nearly all participants.

Sex differences in the preference scores for emotional infidelity relative to sexual infidelity were analyzed with a series of t tests that restricted the data to various degrees (see Table 1). For all choices of all participants, a significant, moderately large effect ($d = 0.49$) confirmed that more women (77%) than men (63%) judged emotional infidelity as more distressing than sexual infidelity (see Table 1).

One reviewer suggested that the size of the sex differences might slowly increase over the course of the six dilemmas in this condition, since the activation of an adaptive jealousy response might be impaired (i.e. slowed) under cognitive constraint (see Barrett et al., 2006). To test this alternative explanation, we ran a separate t test for the first infidelity dilemma and additionally a repeated-measures ANOVA with the six dilemmas as a time factor and linear and quadratic contrasts for time. The sex difference was already present for the first infidelity dilemma ($p < .03$) and did not significantly change over time ($p > .20$ both for the overall time by sex interaction and the linear and quadratic time by sex interactions). Therefore, the effect we found under cognitive constraint cannot be explained by a slow activation of evolved jealousy mechanisms.

Table 1. Sex differences in jealousy: forced-choice and emotion ratings

Jealousy measure	Men			Women			Sex difference			
	N	M	SD	N	M	SD	t*	df	p	d*
Forced-choice, cognitive load [†]	141	0.63	0.30	143	0.77	0.28	4.10	282	.001	0.49
Without high-school degree	38	0.54	0.30	31	0.83	0.25	4.15	67	.001	1.01
With high-school degree	101	0.66	0.29	111	0.75	0.29	2.42	210	.02	0.33
Only valid trials [‡]	140	0.61	0.36	142	0.78	0.29	4.56	280	.001	0.55
Only non-valid trials	128	0.67	0.37	112	0.73	0.38	1.21	238	.23	0.16
Only fast valid responses ^{‡,§}	80	0.63	0.42	99	0.85	0.30	4.06	177	.001	0.61
Negative emotion score	141	3.49	0.73	143	3.76	0.66	3.29	282	.001	0.39
Sexual infidelity	141	3.51	0.80	143	3.72	0.73	2.42	282	.02	0.29
Emotional infidelity	141	3.48	0.78	143	3.80	0.71	3.66	282	.001	0.44
Forced-choice, deliberation [†]	141	0.62	0.36	143	0.77	0.31	3.79	282	.001	0.45
Without high-school degree	38	0.50	0.39	31	0.86	0.22	4.54	67	.001	1.11
With high-school degree	101	0.66	0.33	111	0.74	0.32	1.74	210	.08	0.24
Only slow responses (>20 seconds)	102	0.53	0.43	79	0.63	0.40	1.60	179	.11	0.24

*Positive scores indicate higher scores for women.

[†]Aggregate across six dilemmas. Higher scores indicate greater preference for emotional jealousy.

[‡]Only trials with correctly remembered numbers.

[§]Only trials with responses below 10 seconds.

^{||}Aggregate across three situations and four negative emotion ratings.

A significant interaction in a sex \times education ANOVA indicated that the sex difference was moderated by the educational level of the participants ($F(1,277) = 5.37, p < .02$). As Table 1 shows, the less educated participants showed a stronger sex difference with a large effect size ($d = 1.01$), whereas the better educated participants showed only a small, albeit significant, sex difference ($d = 0.33$).

Next, we compared participants who had carefully followed the instructions with those who had not. To do so, we restricted our data to 'valid' trials, where participants had remembered the six-digit number correctly. Furthermore, the data was restricted to those valid responses where the participants responded within less than 10 seconds (well below the average reaction time of 14.9 seconds). Thereby, we aimed to avoid inclusion of trials where the participants violated the instruction to react spontaneously. According to these two additional criteria, 80 men and 99 women had valid data. Using Fisher's exact tests, we found that women tended to be more compliant with the instruction than men ($p < .05$), whereas there was no significant difference due to education ($p > .30$).

As Table 1 indicates, the sex difference increased when only valid responses were considered and further increased for fast valid responses. The alternative restriction of the data to non-valid trials (i.e. where the memory task was not correctly executed) resulted in a non-significant sex difference (see Table 1). It seems that in these cases, participants had problems with the interfering memory task, which attenuated the sex difference. The interpretation that the non-valid trials were more erratic is also suggested by the consistency of the responses, which tended to be higher for the valid responses (mean correlation across the six dilemmas .30) than for the non-valid responses (mean correlation .23).

Sex differences in the reaction times were analyzed separately for sexual and emotional infidelity choices (see Table 2). A type of infidelity \times sex MANOVA for the log-transformed reactions did not reveal main effects of infidelity type or sex ($F < 1$ in both cases). Thus, decisions for sexual infidelity were as fast as decisions for emotional jealousy, and men and women did not differ in their overall decision time. However, a significant type of infidelity \times sex interaction, $F(1,282) = 5.06, p < .03$, indicated that the sex difference was different for sexual and emotional infidelity. Subsequent *t*-tests showed that women were faster than men when they chose emotional infidelity, whereas an opposite tendency for sexual infidelity was not significant (see Table 2). However, the sex difference for emotional infidelity choices was small ($d = 0.27$). Influences of education on the reaction times were explored in a MANOVA as above, with education as an additional between-subjects factor. All effects involving education were not significant ($F < 1$ in all cases).

Emotion ratings

Sex differences in the emotion ratings were tested in a MANOVA with sex as a between-subjects factor and type of infidelity and type of rated emotion as repeated-measurement factors. There was a significant, moderately large main effect of sex ($F(1,282) = 10.81, p < .001, d = 0.39$), with women rating the infidelity situations overall more negatively ($M = 3.76$) than men ($M = 3.49$). Furthermore, a significant sex \times type of infidelity \times type of emotion effect ($F(3,280) = 5.25, p < .002$) and a marginal sex \times type of infidelity effect interaction ($F(1,282) = 2.16, p = .14$) suggested to analyze the sex effects separately for each infidelity type.

Table 2. Sex differences in jealousy: reaction times

Jealousy measure	Men			Women			Sex difference			
	<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>	<i>t</i> *	<i>df</i>	<i>p</i>	<i>d</i> *
Forced-choice, cognitive load [†]										
Sexual infidelity choices	113	15.80	7.48	84	16.60	8.07	-0.80	195	.43	-0.11
Emotional infidelity choices	134	16.10	7.36	137	14.30	7.08	2.24	269	.03	0.27
Negative emotion score [‡]										
Sexual infidelity	141	6.70	2.97	143	6.44	2.41	0.13	282	.90	0.02
Emotional infidelity	141	7.83	3.18	143	7.32	2.59	1.17	282	.24	0.14
Forced-choice, deliberation [†]										
Sexual infidelity choices	96	20.30	13.10	70	21.20	11.00	-0.64	164	.52	-0.10
Emotional infidelity choices	128	16.40	6.38	138	15.30	6.81	1.92	264	.06	0.24

Note: *M* and *SD* refer to untransformed reaction times in seconds, the *t*-tests to log-transformed reaction times.

*Positive scores indicate faster reactions for women.

[†]Aggregate across six dilemmas.

[‡]Aggregate across three situations and four negative emotion ratings.

For sexual infidelity, a sex \times emotion MANOVA did not reveal a significant interaction effect ($F(3,280) = 1.35, p > .25$). However, a significant sex \times emotion interaction was found for emotional infidelity ($F(3,280) = 4.01, p < .01$). *Post hoc t* tests showed a significant effect of sex for the ratings of jealousy ($t(282) = 4.23, p < .001, d = 0.50$), anxiety ($t(282) = 3.76, p < .001, d = 0.45$) and humiliation ($t(282) = 2.85, p < .001, d = 0.34$), but not for anger ($t(282) = 0.56, ns, d = 0.07$). Thus, the unique lack of a sex effect for anger in the emotional infidelity situation caused the sex \times infidelity \times emotion interaction. Because the other seven sex effects were consistent across emotions, all further analyses used an aggregate of all four emotion ratings as the dependent variable. As Table 1 shows, women reported overall more negative emotions for both sexual and emotional infidelity, with a slightly larger effect size for emotional jealousy.

An education \times sex \times type of infidelity ANOVA revealed a significant three-way interaction on the emotion aggregate ($F(1,277) = 4.27, p < .05$). Separate sex \times type of infidelity ANOVAs for the two educational levels showed that the interaction was not significant for participants with a high-school degree ($F < 1$), but it was significant for those without a high-school degree ($F(1,67) = 5.25, p < .03$; see Figure 2 for the means). *Post hoc t* tests showed that for the less educated participants, the sex difference for sexual infidelity was small and not significant ($t < 1$), but the sex difference for emotional infidelity was significant and fairly large ($t(67) = 2.88, p < .01, d = 0.70$). Figure 2 further illustrates that the education effect was mainly driven by stronger emotional jealousy of less educated women. Thus, in line with the results for the forced-choice paradigm with cognitive constraint, the sex \times type of infidelity interaction was larger for the less educated than for the better educated participants.

The sex differences in the reaction times for the emotion ratings are presented in Table 2. They were tested with an MANOVA with sex as a between-subjects factor and type of infidelity and type of emotion as repeated-measurement factors. All effects involving sex were not significant, particularly the interactions with emotion and infidelity \times emotion ($F < 1$). As Table 2 shows, the sex effects were not even marginally significant for both types of infidelity. Adding education as a between-subjects factor did not yield any significant effects of education. Thus, the reaction time data for the emotion ratings did not

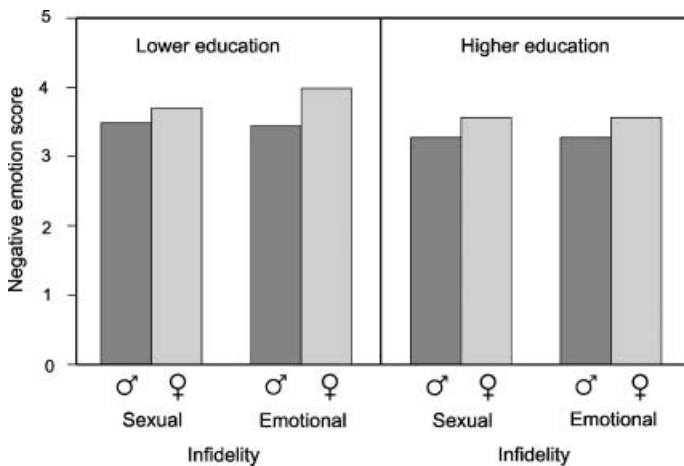


Figure 2. Effects of sex and type of infidelity on jealousy by educational level.

show any significant effects of sex, type of infidelity, type of emotion, education or their interactions.

Forced-choice with deliberation

The participants reacted significantly slower in the deliberation condition than in the earlier forced-choice under cognitive load condition ($M = 16.2$ seconds versus $M = 14.9$ seconds; $t(283) = 4.14$, $p < .001$, $d = 0.35$). Although the size of the difference between the two types of tasks does not appear large, it should be noted that by the time the participants arrived in the deliberate forced-choice condition, they were fairly familiar with the infidelity dilemmas—they had already read them twice. In contrast, participants had confronted the dilemmas for the first time in the cognitive constraint condition. Thus, a familiarity effect interfered with the difference between the two forced-choice tasks. Furthermore, the responses under cognitive constraint were slowed down by the parallel memory test that was difficult for most participants. The existence of a significant reaction time difference between conditions despite these two factors working against it supports that overall our participants complied to the deliberation instruction.

For all choices of all participants, a significant, moderately large effect confirmed that more women than men judged emotional infidelity as more distressing than sexual infidelity (77% versus 62%, $d = 0.45$). This result was highly similar to the one we found in the forced-choice with cognitive constraint condition (see Table 1). Again, a significant interaction effect in a sex \times education ANOVA indicated that this sex difference was moderated by the educational level of the participants ($F(1,277) = 9.30$, $p < .003$). As reported in Table 1, the less educated participants showed a strong sex difference with a large effect size ($d = 1.11$). In contrast, the better educated participants showed only a small, marginally significant sex difference ($d = 0.24$).

The response times were analyzed in the same manner as before for forced-choice under cognitive constraint. A sex \times type of infidelity MANOVA did not reveal a significant effect of sex and also no significant sex \times type of infidelity interaction ($F_s < 1$). However, the sex difference for emotional infidelity was close to being significant ($p < .06$). As Table 2 shows, women chose emotional infidelity somewhat faster than men.

In order to restrict the data to trials where the participants had followed the deliberation instruction, we ran additional analyses based on only the slow responses above 20 seconds (well above the average reaction time of 16.2 seconds). According to this criterion, 102 men and 79 women had valid data for at least one dilemma. Self-selection into this subsample was independent of educational level ($\chi^2 < 1$). The sex difference for slow responses was only marginally significant and small in size ($d = 0.24$, see Table 1). Thus, the sex difference for the deliberate forced-choice task was mainly due to decisions made by less educated participants and based on shorter deliberation.

Forced-choice task summary

Taken together, the results for the two forced-choice tasks suggest consistently that the sex difference for the classic forced-choice task is due to fast, spontaneous decisions, rather than due to long deliberation and that it is more pronounced in less educated participants. Figure 3 presents the means for the four sex \times education groups separately for the fast valid spontaneous and the slow deliberate decisions (not shown in Table 1). Univariate ANOVAs

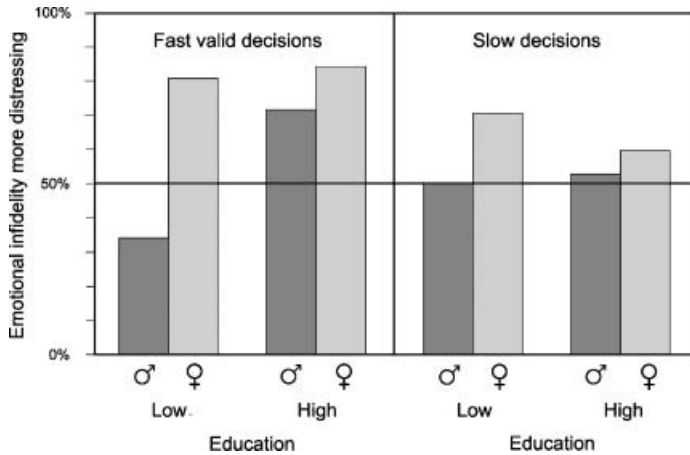


Figure 3. Effects of sex and education on the choice of emotional infidelity as more distressing than sexual jealousy by decision type.

confirmed a significant sex \times education interaction for the fast valid decisions ($F(1,174) = 7.24$, $p < .01$), but not for the slow decisions ($F(1,175) = 1.06$, ns). Figure 3 indicates that the overall sex \times education interaction for forced-choice under cognitive constraint applied also to the subsample of fast valid decisions and was due to a particularly large sex difference for the less educated group. In contrast, this sex difference was smaller for the slow decisions.

A comparison of the mean responses of the four sex \times education groups between the two types of decisions indicated that for each group, the mean for the slow decisions was closer to the chance rate of 50% than the mean for the fast valid decisions (see Figure 3). The mean absolute deviation from 50% was 36% for the fast valid decisions but only 9% for the slow decisions. Thus, both the smaller sex difference and the smaller sex \times education interaction for the slow decisions seem to be due to an increasingly random outcome of the deliberation processes which underlie the slow decisions.³

Relationship effects

All participants had at least once experienced a committed, sexual relationship that lasted at least 1 month ($M = 3.5$, $SD = 2.3$). The couples were together for between 0.67 to 7.96 years when signing up for the study ($M = 2.74$, $SD = 1.63$). The decisions in both forced-choice tasks were highly similar for singles and couples. In two-factorial ANOVAs with sex and relationship status as between-subjects factors, both the relationship status effects and the relationship status by sex interactions failed to reach significance in all cases ($F_s < 1$). Similarly, inclusion of relationship status in the overall MANOVA on the emotion ratings did not show any significant effects involving relationship status. Finally, neither the total number of committed sexual relationships the participants had so far, nor the

³Figure 2 suggests a two-way decision type \times sex interaction and a three-way decision type \times sex \times education interaction. In principle, these interactions could be tested in a MANOVA with sex and education as between-subjects factors and decision type as a repeated measures factor. However, only 90 of the 284 participants had non-missing scores for both types of decisions, which poses problems due to a strong self-selection of the participants and a low power of the statistical tests.

duration of the current relationships of the paired participants were significantly correlated with any of the jealousy measures. Thus, no relationship effects whatsoever were found in this sample.

DISCUSSION

Three main findings emerged in this study, two of which confirmed our hypotheses derived from the literature on sexual versus emotional jealousy. First, the well-replicated finding that women are more likely than men to choose emotional infidelity over sexual jealousy as the more distressing alternative when they are forced to make a choice seems to be the result of spontaneous, automatic reactions, not controlled deliberation: The sex difference persisted under cognitive load, and it was even stronger when we considered only those trials where the participants (1) were successful in executing the simultaneous memory task and (2) made fast, spontaneous decisions within 10 seconds. Furthermore, the difference was smaller when the participants were confronted with the same dilemmas for a third time and made a slow, deliberative decision after 20 seconds or more. This decrease was due to a shift of the decision rates towards chance level. In sum, the results for the two forced-choice tasks clearly support the view that the sex difference in the forced-choice paradigm is due to automatic processes, not to long deliberation.

Second, the results for response measures that were separately obtained for reactions to sexual and emotional infidelity consistently suggested that the sex difference in the forced-choice paradigm is almost exclusively driven by sex differences in emotional jealousy. Women reported more negative emotions than men for both sexual and emotional infidelity, with a marginally significant stronger sex difference for emotional infidelity. Furthermore, women chose emotional infidelity faster than men in both forced-choice tasks, whereas there was no significant tendency of men to choose sexual infidelity faster than women.

Third, neither the current relationship status, nor relationship duration or the total number of committed relationships so far moderated the sex differences in jealousy in this sample of young adults. In contrast, attained education level turned out to be a potent moderator of the sex difference in sexual versus emotional jealousy. Lower educated participants showed a large sex difference with an effect size (Cohen's *d*) above 1.00 for both forced-choice tasks, whereas the sex difference was smaller for higher educated participants. The continuous emotion ratings showed that this relative effect was due to a fairly strong sex difference for emotional jealousy among the lower educated participants (an effect size of 0.70), whereas the sex difference for sexual infidelity was only minimal in this subsample. Thus, education level moderated the sex difference in emotional jealousy, not in sexual jealousy. In contrast, no moderating effect of education was found for the reaction time measures. Thus, the speed of cue processing was not affected by education, while the processes that resulted in forced decisions and emotion ratings were affected.

We will now discuss these key findings in more detail from an evolutionary and cognitive processing perspective.

Sexual jealousy

The early evolutionary discussions of jealousy focused on male sexual jealousy as an evolved adaptation to minimize cuckoldry (Daly et al., 1982; Symons, 1979). However, the

evidence that human males react more jealous to a mate's sexual infidelity than human females is mixed. Such a sex difference was not significantly confirmed by our emotion ratings, nor by any of the 10 similar studies reviewed by Sagarin (2005). Instead, it was reversed in most studies, including our own.

In contrast, the reaction time measures for sexual choices in the two forced-choice tasks in our study as well as in the two studies by Schützwohl (2004, 2005) tended to support the evolutionary hypothesis—though only very weakly: While in all four cases, men chose sexual infidelity faster than women or processed cues for sexual infidelity faster than women, all differences failed to reach statistical significance.⁴

The emotion rating task was most likely affected by the general sex difference that women experience (or at least rate) emotions more intensely than men, particularly in the context of relationship infidelity (see Sagarin & Guadagno, 2004; Nannini & Meyers, 2000). This tendency would decrease or even reverse the evolutionarily expected sex difference.

The bottom line is that if men have indeed evolved a higher sensitivity for sexual infidelity, this tendency seems to interact with so many other factors that the resulting sex difference is minimal, at least in the forced-choice and rating paradigms (for similar evidence, see also Becker, Sagarin, Guadagno, Millevoi, & Nicastle, 2004). One such interacting factor seems to be that male sexual jealousy is increased during the short fertile phase of a partner's ovulatory cycle (i.e. the only period with a real cuckoldry risk, Haselton & Gangestad, 2006; Gangestad et al., 2002; but see Pillsworth & Haselton, 2006). The input that triggers the hypothesized male sexual jealousy module therefore appears to be the simultaneous perception of sexual infidelity cues *and* current fertility cues (see Haselton, Mortezaie, Pillsworth, Bleske-Rechek, & Frederick, 2007; Kuukasjarvi, Eriksson, Koskela, Mappes, Nissinen, & Rantala, 2004; Roberts et al., 2004; Scutt & Manning, 1996; Singh & Bronstad, 2001; Symons, 1995) from the partner. It seems plausible that even men show more immediate emotional than sexual jealousy at other times.

It is important to note that this conclusion does only concern the response to cues of infidelity in the environment, as studied when infidelity scenarios are presented in the forced-choice and rating designs. A sexually dimorphic sexual jealousy mechanism might exist at other levels, for example when freely retrieving jealousy cues from memory (Schützwohl & Koch, 2004; Schützwohl, 2006, Study 1). Such deliberate, higher-level cognitive processes (which are highlighted by Barrett et al., 2006) might be necessary to *anticipate* (and possibly prevent) the threat of sexual infidelity from more subtle cues than the straightforward descriptions of sexual infidelity acts that we used in the present study.

Emotional jealousy

The results for emotional jealousy consistently suggested that women react more jealous to emotional infidelity than men. This sex difference was most obvious in the negative emotion ratings, but also significant for reaction times of forced-choice decisions under cognitive load, where women chose emotional infidelity as the more distressing alternative faster than men, and marginally for forced-choice decisions with deliberation. Together

⁴The reaction times for the emotion ratings are not informative because they did not show any systematic effect for sexual jealousy, emotional jealousy or education. This may be attributed to individual differences in how the participants generated strategies for the execution of the highly repetitive rating task.

with the weak sex difference for sexual jealousy, these findings suggest that the robust sex difference in the classic forced-choice paradigm is mainly driven by a sex difference in emotional jealousy. It should be noted that the ten rating studies reviewed by Sagarin (2005) and the two reaction time studies by Schützwohl (2004, 2005) are also consistent with this view.

Concerning cognitive processes, the larger effect sizes for the sex differences in the cognitive load condition than in the deliberation condition (both for the forced choices and the reaction time data for emotional infidelity choices) consistently suggested that the sex difference for emotional jealousy emerges at the level of automatic processes and drives the sex difference in the classic forced-choice paradigm.

These findings are opposite to DeSteno et al.'s (2002, Study 2) conclusion that the sex difference in the forced-choice paradigm results from deliberate, effortful decisions rather than automatic processes. As Sagarin (2005) pointed out, this conclusion is compromised by the fact that in DeSteno et al.'s (2002) Study 2, significantly more men than women chose sexual infidelity even under cognitive constraint. What remains to explain is the fact that DeSteno and co-workers found smaller sex differences under cognitive constraint than in the consideration condition, whereas we found the exact opposite. We attribute this difference to design problems in DeSteno et al.'s (2002) Study 2, where (1) response reliability was compromised by presenting only one dilemma, (2) sexual infidelity was always presented as the first alternative, (3) participants were forced to respond within a very short time window of 10 seconds and (4) the memory task was very difficult to accomplish. Under these conditions, the participants might have simply tended to choose the first available alternative—sexual infidelity—rather than comparing both alternatives. This would explain the unusually high rate of 65% women choosing sexual infidelity as more distressing than emotional infidelity. Because the order of sexual versus emotional infidelity was counterbalanced across multiple dilemmas in our study, the sample was much larger and the memory task difficulty was more adequate, we are confident that our results are more valid.

Our results also contradict the arguments Tooby and Cosmides (2005, footnote 11), Barrett (2006) and Barrett et al. (2006) presented in response to DeSteno et al. (2002). On purely theoretical grounds, these authors suggested the possibility that activating a jealousy module might require vividly imagining an infidelity situation. In contrast, we found strong empirical support that automatic evaluations are sufficient to elicit systematic and adaptive jealousy responses, at least in women. In contrast, elaborated imaginary processes, as well as other effortful cognitive processes (such as deliberate considerations about gender norm compliance), do not seem to make a noteworthy contribution to the emergence of sex differences in emotional versus sexual jealousy. However, there are others ways for sociocultural factors to systematically influence jealousy reactions, which we will discuss next. For now, we would just like to emphasize that empirical results should always undergo a process of critical methodological examination and replication before they are used for extensive theoretical speculations about human nature.

Environmental influences

According to international comparisons on the Gender Development Index and the Gender Empowerment Measure (United Nations Human Development Program, 2001), Germany can be regarded as having a high degree of gender equality. Indeed, when comparing Germany to other countries (especially the US), sex differences in the classical

forced-choice paradigm are somewhat attenuated, though still clearly existent (Buunk, Angleitner, Oubaid, & Buss, 1996; Hofhansl et al., 2004). The present study is consistent with that, suggesting that choices in the classical forced-choice paradigm are influenced by environmental factors. Such evidence has been used against the hypothesis of jealousy as a specific 'innate' module (Harris, 2003), though it does not contradict the two fundamental evolutionary hypothesis of sex differences in emotional and sexual jealousy. Indeed, Buunk et al. (1996) argued that the sex-specific jealousy modules are best conceptualized as *conditional* adaptations, which are sensitive to the environmental context and adjust their function adaptively to the environmental demands (see also Ellis, Jackson, & Boyce, 2006).

Similar to this cross-population argument for environmental influences on jealousy, the present study allowed for a within-population comparison of cultural influences in a society stratified in educational achievement. As in most other Western countries, sociocultural and socioeconomic conditions vary a lot with educational level in Germany. Because educational level shows a high continuity across generations (e.g. Henz, 1996), educational background can be taken as an indicator of one's developmental conditions: For example, the jealousy modules of our participants without high-school degree were much more likely to develop in an environment with attenuated relationship stability (e.g. White, 1981; Bumpass, Martin, & Sweet, 1991) and increased female competition for good mates (Campbell, 1995, 2004), both of which imply a greater risk of paternal investment loss. If the jealousy module is conditionally adaptive, it should increase female emotional jealousy in such environments. Consistent with this, we found larger sex differences for our lower educated participants that were mainly driven by stronger emotional jealousy of less educated women.

In Germany (e.g. Alfermann, 1996), as in other countries (Kulik, 2002; Quarm, 1983; Togeby, 1995), less educated social strata are also more traditional in their values and gender norms. Such cultural differences between social strata can result from rather arbitrary differences in cultural transmission, or they can be systematically evoked by environmental conditions in an adaptive manner (Gangestad, Haselton, & Buss, 2006). The latter perspective suggests that cultural gender norms for jealousy reactions might be sex-specific adaptive responses to local mating systems. More traditional gender roles that result in a greater female sensitivity to emotional infidelity in social environments with higher female demand for paternal support (such as countries with lower gender equality) or lower certainty of paternal investment (such as lower educated social strata) would thus be an adaptive cultural response that might be evoked by conditional psychological adaptations (Gangestad et al., 2006; Kaplan & Gangestad, 2005; Schmitt, 2005). However, such an interpretation is clearly preliminary and needs further empirical investigation.

Concerning cognitive processing, the effect of educational level on sex differences in emotional jealousy was found in all three conditions, including the one with cognitive constraint. These results suggest that emotional jealousy is already conditional to education-related environmental factors on the automatic level of processing, as one might expect for conditional psychological adaptations. However, the sex difference for the *speed* of emotional infidelity choices was not moderated by educational level. In particular, women without a high-school degree did not choose emotional infidelity faster than women with a high-school degree. This discrepancy suggests that educational level has an effect on the differential weighting of emotional versus sexual infidelity, rather than on the speed of processing infidelity cues. More detailed studies of the different information processes involved in the forced-choice decisions are needed to support this hypothesis.

The education effects in the present study deviate from the findings reported by Green and Sabini (2006) for a national sample, who did not find sex by SES or sex by SES by type of infidelity interactions. One reason for this inconsistency might be that we studied only young adults, who might weight emotional versus sexual infidelity more strongly according to their early developmental environments, than older adults, who might increasingly weight them according to their own experiences.

Reconciling social-cognitive and evolved-modules theories of jealousy

In our opinion, a major issue in the current jealousy debate is the artificial distinction between fixed 'innate' cognitive modules and domain-general social learning processes (Harris, 2003, 2005). Psychological adaptations are much better conceptualized as the result of innate learning preparednesses that canalize experiences (including sociocultural influences) towards the reliable ontogenetic development of functionally specialized cognitive modules (Barrett, 2006; Cummins & Cummins, 1999; Cummins, Cummins, & Poirier, 2003; Figueredo, Hammond, & McKiernan, 2006; Tooby et al., 2005). What is selected for in the evolutionary process, then, is not a cognitive module, but a *developmental system* that interacts with relevant aspects of the individual environment in developing a cognitive module (Barrett, 2006). Such developmental systems can encompass various elements of the organism that do not need to be specific for the resulting module—what matters is that certain aspects lead to the reliable development of a specialized cognitive module with functional design (Tooby et al., 2005).

This view makes it easier to reconcile cognitive modules with traditional social-cognitive theories of jealousy than an assumption of innate, fixed cognitive modules. Social-cognitive theories argue that jealousy is a general mechanism that motivates behaviour to protect the self against threats from a rival. A developmental canalization perspective does not refuse the existence or involvement of more general motivational mechanisms that are not unique to jealousy, like the maintenance of self-esteem (Tooby et al., 2005). Sociometer theory, for example, regards general self-esteem as an evolved affective mechanism that monitors an individual's risk of social rejection (Leary & Baumeister, 2000; Leary, Tambor, Terdal, & Downs, 1995). However, only certain forms of social rejection (such as being left by a mate for a rival) are evolutionarily costly (see Kirkpatrick & Ellis, 2001) and should therefore reliably evoke behavioural counteractions. Even in an environment with socioculturally predefined knowledge structure, such specific behavioural tendencies cannot be learned by general-purpose mechanisms alone (Tooby et al., 2005; see also DeSteno et al., 2006). Therefore, evolutionary psychologists argue for the existence of innate, domain-specific psychological competences that evolved to canalize the interactions of other, potentially more general psychological mechanisms and environmental factors towards adaptive functional design.

From this developmental canalization perspective, there might very well be a rather domain-general jealousy mechanism that is connected to self-esteem as an interpersonal monitor (*sensu* sociometer theory) and that helps to protect important personal relationship from rivals (as proposed by the social-cognitive theory of jealousy). However, the critical assumption is that domain-specific competences provide this general jealousy mechanism with highly specific input, thereby ensuring the reliable development of a jealousy mechanism that serves an adaptive function. These competences include, among others, a positive valuation of romantic partners (i.e. infatuation and romantic attachment, Fisher,

2004), a valuation of same-sex rivals as threatening (Maner et al., in press) and the specifically female weighting of cues to emotional infidelity as especially alerting (Buss et al., 1992). Such a conceptualization can also easily account for the conditional nature of jealousy (as found by Buunk et al., 1996), since the sociocultural contexts in which individuals develop their jealousy modules might differ in a predictable way in how much they enforce the reliance of the general jealousy mechanism on certain competences.

Resolving apparent inconsistencies across methods

Our cognitive processing perspective has proved helpful for integrating apparently inconsistent findings across different methods, both in our own study and in the literature. In the recent controversy about sexual and emotional jealousy, most seem to believe that the results of the forced-choice paradigm and the separate rating paradigm are inconsistent (e.g. Harris, 2003, 2005; Sagarin, 2005). We suggest that this is not true. Instead, the pattern of results, including our own, suggests that the apparent reversal of the sex difference for ratings of sexual jealousy is due to later stages of processing, where initial feelings of jealousy are overridden by a general female tendency to experience or report emotions in a relationship context more strongly than men (Nannini & Meyers, 2000; Sagarin & Guadagno, 2004). Even though Barrett et al. (2006) stress that evolved adaptations do not *need* to be implemented at lower, automatic levels of cognitive processing, our results, along with those of Schützwohl (2004, 2005), suggest that at least some of the cognitive processes involved in the function of sex-specific jealousy modules—especially those involved in the sex-specific weighting of cues for emotional infidelity—operate at the automatic level. In addition, our results contradict the speculation by Tooby and Cosmides (2005) and Barrett et al. (2006) that cognitive loads interfere with the evolved jealousy mechanism. This highlights the fact that empirical replications are indispensable before strong theoretical conclusions should be drawn. We therefore encourage further studies, especially on the level of proximate cognitive mechanisms, in order to settle the current debates over the nature of romantic jealousy.

Strengths and limitations of the present study

This study has multiple strengths, including the systematic variation of the automaticity of the jealousy responses, the greater reliability of the jealousy assessments due to the aggregation of various infidelity dilemmas instead of only one or two, the recording of the response times for all decisions and ratings, validity checks for the proper execution of the cognitive load task and a sample that was sufficiently large for the detection of small effects and quite diverse in terms of the educational level and the relationship status of the participants, while comparable to the majority of other studies in terms of age.

At the same time, our findings are limited by the fact that only one culture was studied, which did not allow us to provide strong support for the adaptive plasticity of human jealousy. Furthermore, only jealousy measures based on hypothetical situations were used. However, the alternative use of recalled actually experienced situations (see Harris, 2003, for a review) is compromised by memory biases (including systematic sex-specific biases, e.g. Brown & Sinclair, 1999; Schützwohl & Koch, 2004). Furthermore, the reliance on only one recalled situation limits the reliability of the responses, whereas a reliance on participants with many infidelity experiences would introduce a serious selection bias in the sample.

While the fixed order of the three experimental conditions might be considered as a limitation of the present study, we rather consider it as a strength. It would make no sense to counterbalance the order of spontaneous versus deliberate decisions, because asking participants for spontaneous decisions after they have already made deliberate ones on the same scenarios could not exclude the possibility that deliberate, rather than spontaneous, decisions are given and thus may lead to artificial results. The only alternative would be to vary the conditions between participants, but this would either require an unreasonably large sample, or it would seriously limit the sample size in each condition (as exemplified in the study by DeSteno et al. (2002), who relied on less than 60 students in the cognitive constraint condition). Because we also wanted to study moderator effects of relationship status and education, even 100 participants within each condition would have been insufficient for the expected small to moderate effects. Therefore, fixing the order of conditions the way we did it appears to be the only reasonable and tenable alternative.

Back to evolutionary psychology as the ‘missing link’

Twenty years ago, Cosmides and Tooby (1987) introduced evolutionary psychology as the field that studies evolved psychological adaptations—the ‘missing link’ between evolution and behaviour. Unfortunately, publications in this area still focus on testing evolutionary expectations on the behavioural level. We believe that evolutionary psychology in general will benefit greatly from spending more effort on the specific description and empirical testing of psychological mechanisms. Our study is a step in that direction, and we hope that it will inspire evolutionary psychologists interested in this and other domains of psychological functioning to move from ultimate expectations to the detailed study of proximate cognitive mechanisms (see also Maner et al., 2003, 2007, in press; Miller, 1997; Mata, Wilke, & Todd, 2005).

Both the sex differences in sexual and in emotional jealousy are specific hypotheses that are deduced from a mid-level evolutionary theory (i.e. the parental investment theory by Trivers, 1972) which is itself inspired by the metatheory of Darwinian evolution (see Buss, 1995; Ketelaar & Ellis, 2000). As the findings for sexual jealousy illustrate, not everything that could be ultimately expected from an evolutionary perspective was in fact implemented as psychological adaptations during human evolution, or may not be implemented in a manner that appears plausible at first glance. The task for psychologists is to identify the concrete cognitive processes underlying these proximate mechanisms. Since the falsification of specific hypotheses does not imply the immediate rejection of a mid-level theory, let alone a metatheory (Holcomb, 1998), this task should be guided by ultimate, evolutionary expectations. Such expectations, however, cannot replace the tedious task of studying the proximate mechanisms in detail.

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APPENDIX

Sequence of situations for the forced-choice under cognitive constraint task (jealousy dilemmas in italics)

It would distress or upset me more, if my partner . . .	
1. is unfriendly with my family	is unfriendly with my friends
2. lies to me	steals something from me
3. <i>enjoys passionate sexual intercourse with another person</i>	<i>forms a deep emotional attachment to another person</i>
4. forgets my birthday	forgets our anniversary
5. <i>falls in love with another person</i>	<i>tries different sexual positions with another person</i>
6. has no time for me	leaves no room for me
7. deceives and exploits his/her friends	is exploited by others
8. <i>has sex with someone else, no matter how much he/she feels for in that person</i>	<i>starts to develop an emotional attachment to someone else, no matter if sex plays a role or not</i>
9. does not care for his/her looks	acts impolite again and again
10. <i>forms a deep emotional attachment to another person, but you are certain they will not have sex</i>	<i>has sex with another person, but you are certain they will not form a deep emotional attachment</i>
11. criticizes me all the time	ignores me all the time
12. <i>is still sexually interested in his/her former lover, but is no longer in love with this person</i>	<i>is still emotionally involved with his/her former lover, but is no longer sexually interested in this person</i>
13. comes too late for a date with me	does not show understanding if I am somewhat late
14. <i>becomes emotionally involved with another person, with no chance of any sexual involvement</i>	<i>has sex with another person, just once, with no chance of any further involvement</i>
