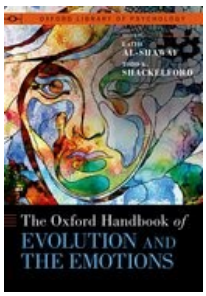

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CHAPTER

21 How Jealousy Works

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Abstract

This chapter seeks to invigorate work at the boundary of knowledge about jealousy. First, the chapter conducts a task analysis of the adaptive problem that jealousy is hypothesized to solve. This task analysis reveals key gaps in current knowledge about jealousy. Second, the chapter presents an array of new, testable hypotheses about this important human emotion. These include hypotheses about within-sex individual differences (in contrast to the historical emphasis on between-sex differences), hypotheses about within-individual shifts in jealousy over time, and hypotheses about the distinct tactics the jealousy system should deploy in response to different forms of relationship threat. Finally, the chapter emphasizes the need for more research on jealousy in relationships other than monogamous mating relationships, including consensually non-monogamous relationships as well as non-mating relationships. This chapter contributes novel theoretical insights and suggests future directions that can help generate new empirical discoveries about this important human emotion.

Keywords: sexual jealousy, human mating, mate retention, infidelity, individual differences, sex differences, friendship jealousy

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Introduction

Recently, major strides have been made toward mapping the design features of emotions such as anger (Sell, 2005, 2011; Sell, Sznycer, et al., 2017), shame (Sznycer, 2010; Sznycer et al., 2012; Sznycer et al., 2016), pride (Sznycer et al., 2017; Sznycer et al., 2018; Sznycer & Cohen, 2021b), and many others (this volume). Few emotions, however, have received as much theoretical and empirical attention as jealousy (see Buss, 2013, for review). Precisely because jealousy is already one of the best-characterized emotional adaptations, at this stage it may be most productive not to ask what the design features of jealousy are, but rather what design features of jealousy have not yet been investigated and identified. We hope that this chapter usefully orients researchers in this manner; although a great deal is known about the design of the jealousy program, there is still much exciting work to do.

This chapter takes two steps toward invigorating work at the boundary of knowledge about jealousy. First, other resources (e.g., Buss, 2013) provide thorough descriptions of known design features of jealousy. However, these resources tend to follow an organization (e.g., centered on sex differences) that does not readily reveal where gaps in knowledge remain. By contrast, organizing an emotion program's design features chronologically, using a task analysis—from the initial inputs that activate the program; through
p. 392 the operation of ↳ cognitive, affective, and behavioral design features that the program coordinates to solve the relevant problem; to the program's deactivation once cues indicate that the problem has been resolved—may be a more systematic means of revealing which features of the emotion remain unmapped. In this chapter, we take this approach: we conduct a task analysis of the problem that jealousy is hypothesized to have evolved to solve, and, in doing so, draw attention to key aspects of the jealousy program that remain unknown.

Second, we advance numerous new hypotheses about the operation of jealousy. These include hypotheses about within-sex individual differences (in contrast to the historical emphasis on between-sex differences), within-individual shifts in jealousy over time, and the specific behavioral outputs that jealousy deploys in response to distinct contextual factors. Some of these new hypotheses appear naturally as we organize already-known features of jealousy chronologically (around a task analysis), whereas others appear in a dedicated "Future Directions" section at the end of the chapter.

We focus on jealousy in the context of mating relationships. Although important strides have recently been made toward an understanding of "friendship jealousy" (e.g., Krems et al., 2021; see also Schützwohl et al., 2019), and intriguing adaptationist hypotheses have been advanced about jealousy in the context of kin relations (e.g., sibling jealousy; Hart, 2018), it is unclear whether these represent different psychological mechanisms (Schützwohl et al., 2019) or the operation of the same information-processing system across different relationship types. Given these issues and uncertainties—to which we return in the "Future Directions" section below—we focus on the well-characterized design and operation of jealousy in mating relationships.

The Adaptive Problem

The key first step in a priori, theory-driven evolutionary research is to identify the selection pressures—the adaptive problem—thought to have driven the evolution of the hypothesized adaptation under investigation (Tooby & Cosmides, 1990, 1992; Williams, 1966; see also Lewis et al., 2017; Lukaszewski et al., 2020). Ancestrally, infidelity or abandonment by one's romantic partner would have posed substantial costs to both males and females (Buss, 2000; Buss et al., 1992; Wilson & Daly, 1996). This recurrent adaptive problem is hypothesized to have caused the evolution of an information-processing program—*jealousy*—that detects and appraises threats to a valued relationship, and coordinates behavior to thwart those threats (Buss, 1988; Buss & Shackelford, 1997; Daly et al., 1982).

The Solution

The second step in adaptationist research should be to conduct a task analysis of that problem: to elucidate the exact nature of the problem and articulate the features that a system is expected to have if it is an adaptation that evolved to solve that problem.

At one level of abstraction, the historical research on jealousy could be regarded as being based on such a task analysis. Broadly, research has shown that the jealousy program activates in response to cues to a partner's possible infidelity or defection, and that it motivates behaviors that plausibly function to thwart the threat. At a more precise level, research has shown that jealousy activates in response to numerous specific situational inputs probabilistically indicative of infidelity (e.g., see Shackelford & Buss, 1997b) and identified a diverse suite of behavioral outputs that the jealousy program mobilizes to ward off threats to the valued relationship (Buss, 1988). Indeed, whereas the tactical behavioral outputs of other emotion programs are yet unknown, research on jealousy established an inventory of the program's behavioral outputs over 30 years ago (see Buss, 1988).

Jealousy: At the Forefront, but Important Work Remains

Initial research on jealousy was ahead of its time, perhaps both for better and worse. It was at the front line of introducing an evolutionary meta-theoretical framework to the study of human emotion—one could argue that, for many years, it was one of the only emotions being earnestly investigated through an adaptationist lens. A potentially negative consequence of jealousy being at the vanguard of adaptationist research on human emotion, though, is that important investigations of jealousy took place prior to the publication of several formative papers in evolutionary psychology and therefore could not take full advantage of important conceptual tools that appeared in those papers. In particular, early work on jealousy focused more on sex differences and less on the sequence of information-processing and behavioral coordination steps necessary to solve the adaptive problem. Consequently, although the highly productive program of research on jealousy made many discoveries, it may not have mapped the emotion's underlying cognitive architecture as systematically as it would have if it had been driven by a chronological task analysis.

More recent work on other emotions, such as Sell and colleagues' work on anger (e.g., Sell, 2005, 2011; Sell, Sznycer, et al., 2017), has been more closely guided by such a task analysis. This has enabled it to illuminate key features of the emotion's information-processing and behavioral coordination design. First, anger activates when ego perceives that someone else has placed too little value on ego's welfare. Second, the program mobilizes cognitive systems to determine whether this initial perception is accurate, including motivating behaviors to acquire further information to confirm or disconfirm the original assessment. Third, if the initial assessment was correct—if the target indeed placed too little value on ego's welfare—the anger program organizes behaviors that interface with cognitive systems in the target's mind to increase the value that the target places on ego's welfare. Finally, anger deactivates when the costs of its continued operation exceed the benefits (for example, when it receives inputs indicating that the value that the target places on ego has been upregulated) (see Sell, 2005, 2011; Sell, Sznycer, et al., 2017; see also Al-Shawaf & Lewis, 2017; Lukaszewski et al., 2020).

Although research on jealousy has documented an extensive catalog of inputs that activate the program, and a diverse taxonomy of tactical behavioral outputs that the emotion mobilizes, a more systematic and detailed task analysis may better organize these features of jealousy and may also lead to the discovery of previously unknown components of jealousy's behavior-coordinating architecture. For example, the Mate Retention Inventory (MRI; Buss, 1988; Buss & Shackelford, 1997; Shackelford et al., 2005) is perhaps the

most extensive taxonomy of behavioral outputs coordinated by an emotion program, with over 100 acts organized into 19 different act clusters or "tactics." Similarly, Shackelford and Buss (1997b) identified over 100 cues to infidelity (i.e., inputs to the jealousy program), and organized these cues into 14 distinct factors. Despite the comprehensiveness and many other merits of these taxonomies, they do not address two important features of jealousy's information-processing design.

First, the MRI does not elucidate the *sequential* nature of the task of detecting, appraising, and warding off infidelity threats. For example, behaviors such as "He read her personal mail" and "He hit the guy who made a pass at her" are found in categories of behavior that, in the hierarchy of the MRI, are parallel. This parallel categorization does not effectively capture that these tactics tend to be deployed at different stages of solving the relevant adaptive problem. The former behavior may be an initial output of jealousy to monitor for or acquire further information about a potential threat. The latter behavior, on the other hand, is more characteristically an output mobilized at a later stage (e.g., in response to a confirmed threat). This is not to say that the MRI explicitly advances the idea that these behaviors are alternatives to one another at a single stage. Rather, because the MRI is principally organized by the *target* of ↳ the behavior (i.e.,
p. 394 *intersexual manipulations* directed at ego's mate vs. *intrasexual manipulations* directed at potential mate poachers), rather than by a task analysis of the adaptive problem, the MRI does not effectively capture the sequence of information-processing and behavioral coordination steps necessary to solve the relevant adaptive problem.

Second, the MRI is a taxonomy of outputs that is largely independent of the inputs that activate jealousy, and Shackelford and Buss's (1997b) "Cues to Infidelity" is a taxonomy of inputs that is largely independent of the behavioral outputs in response to them. In other words, existing research does not clearly specify input-output mappings for this emotion. As Buss (2013) notes, there are many distinct instantiations or subclasses of the broad adaptive problem of infidelity: one of ego's same-sex rivals could show an interest in ego's mate; ego's mate could give off cues of interest in another party—or merely of sexual disinterest in ego; or, if ego's mate is significantly higher in mate value than ego, this enduring feature of the relationship could pose a looming threat of infidelity or abandonment (Buss, 2000). Each of these distinct scenarios falls into the abstract class of cues that are expected to be inputs that activate jealousy. However, these distinct scenarios require different cognitive, affective, and behavioral solutions. To take just one example, inflicting costs on an intrasexual rival may be an effective strategy for deterring a potential mate poacher, but is not an effective tactic for solving the problem of a mate who has fallen out of love with ego.

These limitations represent an opportunity for jealousy research—one that is particularly ripe precisely because scholars have already established these valuable taxonomies of inputs and outputs. Coupled with these resources, a systematic task analysis—including distinct analyses of the different problems posed by distinct instantiations of infidelity threat (e.g., a rival is attempting to poach one's mate vs. one's mate has wandering eyes)—should enable researchers to organize jealousy's outputs according to the functional sequences in which they are deployed, and to make progress toward *specific* input-output mappings (see Sznycer & Cohen, 2021a; see also Al-Shawaf et al., 2016).

Jealousy: A Task Analysis

Step 1: Detect and Activate in Response to Cues of Relationship Threat

The first step in solving the adaptive problem of a mate's potential infidelity or defection is to detect cues to that threat and activate in response to them. This is exactly what the jealousy system does. Jealousy "lie[s] dormant until [it is] activated by cues signaling that [the] adaptive problem is being confronted" (Buss & Shackelford, 1997, p. 348). Empirical research has demonstrated that jealousy activates in response to dozens of distinct cues to infidelity (Shackelford & Buss, 1997b), and that this activation is associated with the mobilization of physiological, psychological, and behavioral resources (Buss et al., 1992; Pietrzak et al., 2002).

However, jealousy's mobilization of behavioral outputs can carry significant costs, including time, energy, and opportunity costs. These costs will often be outweighed when there is a veritable infidelity threat. However, false positives—anti-infidelity behaviors when there is no real infidelity threat—not only entail wasted effort, but also may jeopardize the very relationship that the jealousy program is trying to protect (Barelds & Barelds-Dijkstra, 2007). Consequently, we should expect jealousy to be designed to avoid the dual errors of over-activation (i.e., mobilization of further resources in the absence of real infidelity threat) and under-activation (i.e., the failure to mobilize resources in the presence of true infidelity threat) (see Sznycer, 2019, for a discussion of this "just right" Goldilocks principle in the design and operation of psychological adaptations, including emotions).

Schützwohl's (2006) data are consistent with this Goldilocks principle. Schützwohl presented males and
p. 395 females with a description of one of two scenarios, both of which depicted ↳ their partner meeting a potential interloper. However, the two scenarios differed in their infidelity likelihood. In one scenario, the partner voluntarily disclosed meeting the other person. In the other scenario, the meeting was not openly disclosed, and the partner came home late on multiple occasions. Consistent with the Goldilocks design principle, participants in the lower infidelity likelihood condition exhibited significantly lower activation of the jealousy program, whereas participants in the higher infidelity likelihood condition exhibited greater activation of jealousy (see also Lewis, Lukaszewski, et al., 2023).

Step 2: Appraise the Threat

After activating, jealousy should continue to exhibit the Goldilocks principle. This means that even after it activates in response to probabilistic cues to infidelity, it should not automatically mobilize its full arsenal of anti-infidelity outputs. Instead, we should expect jealousy to first deploy less costly tactics, such as information search, to determine whether the initial perception of a threat was accurate (see Sell, Sznycer, et al., 2017, for evidence of this design principle in the context of anger), identify the principal cause of the threat (e.g., a cause exogenous to the relationship such as an interested mate poacher or an endogenous cause such as an unsatisfied mate), and ascertain the type of threat (i.e., emotional infidelity versus sexual infidelity). At present, some of these features of jealousy have been thoroughly investigated, whereas others have not.

The Type of Threat: Sexual Infidelity vs. Emotional Infidelity

In monogamous relationships, extra-pair emotional intimacy and extra-pair sexual relations are both considered forms of infidelity (Kruger et al., 2013; Thornton & Nagurney, 2011). However, sexual infidelity and emotional infidelity are distinct adaptive problems, and the consequences of those problems differ for males and females.

Because fertilization occurs internally in human females, they can always be assured of the maternity of their offspring, whereas males can never be 100% certain of their paternity. As a result, males (but not females) risk unknowingly investing valuable time and resources in offspring that are not biologically their own. Consequently, across deep evolutionary time, a mate's *sexual infidelity* would have been costlier to males than to females (on average). We should therefore expect the jealousy program to exhibit sex-differentiated design features in response to the threat of sexual infidelity (see Symons, 1979).

Although it does not jeopardize a female's maternity when her male partner engages in extra-pair affairs, such affairs can still carry large costs for the female, in particular if they are accompanied by a diversion of her mate's time, effort, attention, and investment away from her and her offspring (Buss, 2013). This *emotional infidelity* would have posed an acute adaptive problem for females for multiple reasons, including decreased offspring survival in the absence of an investing mate (Hurtado & Hill, 1992). We should therefore expect the jealousy program to exhibit sex-differentiated design features in response to a mate's emotional infidelity as well (Symons, 1979).

Consistent with these hypotheses, Buss and colleagues (1992) showed that males exhibited more pronounced physiological, psychological, and behavioral responses to sexual infidelity than to emotional infidelity, whereas the opposite pattern was observed among females. Males' responses to sexual infidelity, compared to their responses to emotional infidelity, were associated with greater upset, increased skin conductance, increased heart rate, and greater contraction of the corrugator supercilii ("frowning") muscle. Females, on the other hand, exhibited greater electrodermal activity, heart rate, and electromyographic activity in response to emotional than sexual infidelity (Buss et al., 1992). These observed sex differences in
p. 396 response to ↳ sexual versus emotional infidelity have been robustly replicated using both forced-choice and continuous-rating measures, as well as both hypothetical and actual infidelity experiences, and have been extended to include changes in skin temperature and neurophysiological activation as assessed by functional magnetic resonance imaging (see Becker et al., 2004; Edlund et al., 2006; Pietrzak et al., 2002; Shackelford et al., 2000; Takahashi et al., 2006). Sex differences in the operation of jealousy have also been replicated across diverse cultures, including multiple non-WEIRD cultures and traditional societies (Scelza et al., 2020).

These findings demonstrate that jealousy operates in a sex-differentiated fashion, in line with a priori hypotheses based on sex-differentiated selection pressures. However, it is not clear at exactly which stage(s) of information processing and behavioral coordination these psychological and physiological features of jealousy (e.g., upset, increased heart rate) contribute to solving the adaptive problem of infidelity threat. This issue is compounded by the fact that these responses have been documented primarily in response to *confirmed* infidelity rather than in response to cues indicating *possible* infidelity. Consequently, the research documenting these responses to confirmed infidelity may not reveal exactly what people do when they detect *ambiguous* cues to infidelity threat. We are unaware of any lab or group of researchers programmatically investigating the operation of jealousy during this key stage of threat appraisal. However, distinct findings from independent laboratories begin to paint a picture of some of jealousy's design features at this initial stage of addressing the adaptive problem.

Information Acquisition: Directly Questioning One's Partner about the Type of Infidelity Threat

One way to obtain further information about a potential threat is to directly question one's partner. Several studies suggest that such direct interrogation may be an important feature of jealousy. Buss (1988), for example, found that the mate retention tactics deployed by American undergraduates included behaviors such as "questioned my partner about what she did when we were apart." However, this and other interrogative behaviors were not differentiated with respect to whether information was being sought about sexual versus emotional infidelity. Because of sex differences in the costs of sexual versus emotional infidelity, we should expect males to be more focused on acquiring information about the threat of sexual infidelity, and females to be more focused on acquiring information about emotional infidelity.

This appears to be precisely what they do. Schützwohl (2006) found that, when males and females were asked what they would do if they learned that their partner had spent time with a potential mate poacher, males were more likely than females to indicate that they would seek information about possible sexual aspects of the encounter, whereas females were more likely than males to indicate that they would seek information about their partner's emotional closeness to the potential interloper. Kuhle and colleagues (Kuhle, 2011; Kuhle et al., 2009) found similar sex differences, although they were not investigating people's responses at the initial stage of assessing and appraising a threat—rather, they investigated how people interrogate their partners *after certain infidelity* had already occurred. When they learned about their partner's extra-pair relationship, females were more likely than males to seek information about whether their partner was in love with the interloper, whereas males were more likely than females to ask questions about sexual infidelity.

These findings make important contributions toward understanding the design and function of direct interrogation tactics. However, we should expect jealousy to motivate subtler behaviors than blunt questions such as "Have you slept with him?" (Schützwohl, 2006, p. 287) or "Do you love her?" (p. 288). It can be very costly to the unfaithful partner to reveal that they have been unfaithful, so directly interrogating
p. 397 a partner about their fidelity will ↳ often yield inaccurate information (see Andrews et al., 2008; Cole, 2001; Kuhle et al., 2009). Additionally, we should expect direct interrogation to have more nuanced functions than simply to determine whether sexual or emotional infidelity has already occurred. If a key function of jealousy is to *prevent* infidelity, then it should motivate people to acquire information about the likelihood of *future* infidelity. Based on these considerations, jealousy should motivate people to seek information about much more than just their partner's past behavior and the type of infidelity, and to acquire that information through subtle as well as furtive means.

Information Acquisition: Subtle Interrogation Tactics about the Cause

A system that evolved to prevent infidelity should seek information about the cause of infidelity threat (e.g., an endogenous cause such as a mate who is actively engaging in extra-pair mating effort, versus an exogenous cause such as a rival showing interest in one's mate).

Identifying the precise cause of the threat is crucial. The jealousy program can deploy many different behavioral outputs, but the usefulness of any given output will be tightly linked to the cause of the problem. For example, behaviors such as "Threatened to hit a man who was making moves on my partner" (Buss, 1988) may be successful for dealing with an encroaching mate poacher but futile for solving the problem of a mate who has fallen out of love with ego. We should therefore expect the jealousy program to motivate interrogation tactics that are designed to acquire detailed information about the cause of the threat.

Schützwohl's (2006) data are consistent not only with the hypothesis that the jealousy program searches for information about the occurrence and type of infidelity, but also with the hypothesis that jealousy

specifically seeks information about the *cause* of infidelity. For example, when people inquired about their partners' emotional involvement with an interloper, they asked not only about whether their partner was in love with the interloper, but also about whether their partner still loved them (the participants). This makes sense because a partner being in love with someone else and a partner falling out of love with ego are two different problems with distinct behavioral solutions. People also sought information from 10 categories that were *not* directly about whether emotional or sexual infidelity had occurred. For example, people asked about the *circumstances* in which their mate met the rival as well as about *aspects of the rival*.

These questions about *circumstances* and *aspects of the rival* may reflect important features of the jealousy program. For example, acquiring information about the circumstances in which one's mate met the interloper could alert one to the specific environments (e.g., work), individuals (e.g., one's mate's new boss, who likes to take his employees out for drinks), times (e.g., after work), and other situational variables linked to an increased likelihood of subsequent encounters with the current interloper or other potential future interlopers. The purpose of asking questions about *aspects of the rival* may be to gather information about the physical phenotype of the rival, including the rival's physical attractiveness. Because males, on average, place greater value on a potential mate's physical attractiveness than females do (e.g., Buss, 1989; Li et al., 2002; see also Lewis et al., 2011; Lewis et al., 2012), we might expect female jealousy to be more sensitive to a rival's physical attractiveness. Consistent with this, evidence suggests that, on average, rival attractiveness has stronger effects on female than male jealousy (e.g., Dijkstra & Buunk, 1998, 2002; replicated by Pollet & Saxton, 2020).

Although existing research sheds light on some of these facets of jealousy, there are several key design features that remain unaddressed. For example, broadly defined categories such as *aspects of the rival* do not differentiate between characteristics such as physical attractiveness and social status. Because females, on average, place greater value on a potential mate's social status than males do (e.g., Buss, 1989; Li et al., 2002), male jealousy may be more sensitive to a ↳ rival's status (Dijkstra & Buunk, 1998, 2002; but see Pollet & Saxton, 2020). Collapsing rival characteristics into a single category prevents more nuanced analyses to determine whether males and females seek different information about their rivals.

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Similarly, questions such as "May I see him/her?" (Schützwohl, 2006) are not sufficiently specified to determine whether males and females are seeking *different* information when they engage in information search about the physical phenotype of rivals. For example, because physical formidability likely has a greater impact on male intrasexual competition (Sell et al., 2012) *and* female mate choice (e.g., see Frederick & Haselton, 2007; for review, see Lewis, Evans, & Al-Shawaf, 2023), males may be more motivated than females to seek information about the rival's physical formidability. Similarly, we might expect information search to be tied to an individual's specific weaknesses or worries—for example, individuals who perceive their careers or material resources to be lacking might be more motivated to seek information about these specific attributes in the rival. These hypotheses about the operation of jealousy at the threat appraisal stage await future testing.

Information Acquisition: Surreptitious Behaviors

An unfaithful mate may suffer severe costs if they reveal their infidelity to their partner, even if only via indirect cues. Such costs could include their partner attempting to thwart the affair, engaging in a retaliatory affair, or terminating the relationship. Consequently, unfaithful mates may lie or actively mislead their partners (Cole, 2001; Kuhle et al., 2009). We should therefore expect the jealousy program to seek information without relying on the direct testimony of the mate. Consistent with this, Buss (1988) found that mate retention tactics include behaviors to acquire information about infidelity threat without relying on information from one's partner. Moreover, these behaviors appear designed to avoid revealing one's own suspicions. This may be strategic: if one's mate becomes aware of one's suspicions, one's mate might make a greater effort to conceal information about their infidelity, or, if they are actually faithful, such unjustified suspicions could jeopardize the relationship (Barelds & Barelds-Dijkstra, 2007). These tactics to surreptitiously acquire information about infidelity threat include behaviors ranging from "Dropped by unexpectedly to see what my partner was doing" to "Read my partner's personal mail." They also include information-acquisition behaviors that involve third parties, such as "Had my friends check up on my partner" (see Buss, 1988). The recruitment of third parties may serve several potential functions. These include acquiring information when one is unable to be present (but see Russell et al., 2017; Russell et al., 2018), as well as more easily hiding one's suspicions from one's partner (for a broader discussion of "coalitional" mate retention tactics, see Pham, Barbaro, & Shackelford, 2015). These hypotheses about the distinct functions of such indirect means of information acquisition and the specific contexts in which they are deployed remain to be rigorously tested (see also Barbaro et al., 2015; Pham, Barbaro, Mogilski, & Shackelford, 2015).

Inferences under Uncertainty: Threat Appraisal Biases

An ideal information-processing system would make accurate inferences about the presence or absence of infidelity threat 100% of the time. However, in the real world, inferences about infidelity must almost always be made under conditions of uncertainty—especially if unfaithful mates actively conceal cues to infidelity. In such a world, inferential errors are inevitable. The two possible inferential errors—false positives (inferring the presence of infidelity threat when it is absent) and false negatives (inferring the absence of infidelity threat when there is a real threat)—have asymmetrical costs, which can select for
p. 399 cognitive biases (see Haselton & ↳ Buss, 2000), including sex-differentiated biases when the cost asymmetry differs between the sexes (see also Al-Shawaf, 2016a; Lewis, Al-Shawaf, Semchenko, & Evans, 2022).

The false negative of erroneously inferring that a partner has been *sexually* faithful is costly for both males and females, but it is costlier for males than females because only males can unwittingly raise somebody else's child. We might therefore expect any cognitive biases toward false positives about a mate's sexual infidelity to be more pronounced among males. Consistent with this hypothesis, Andrews and colleagues (2008) found that males, relative to females, had a higher ratio of false positive errors to false negative errors when making inferences about whether their partner had been unfaithful (see also Goetz & Causey, 2009). We are not aware of any research testing for sex-differentiated biases in inferences about *emotional* infidelity. However, to the extent that a partner's emotional infidelity was costlier, on average, to females than to males—and a false negative about a partner's emotional infidelity was therefore costlier to females—we might expect a sex difference in the opposite direction. We await future research testing this hypothesis.

Step 3: Defend against the Threat

If the jealousy program infers that there is indeed an infidelity threat—as a consequence of any combination of initial cues, subsequent acquisition of new information, and inferences under uncertainty—we should expect it to mobilize behaviors to prevent the perceived threat from translating into actual infidelity. Reducing the likelihood of infidelity can be achieved through a variety of means, reflected by the diverse tactics in the Mate Retention Inventory.

Although these distinct tactics all share the same abstract function of defending against infidelity threat, they operate at a more specific level. Some tactics, such as *concealment of mate* and *monopolization of mate's time*, achieve their function by keeping one's mate away from environments associated with infidelity threat. Other tactics interface with cognitive systems in the mind of a potential mate poacher. For example, tactics such as *intrasexual threats* and *violence* use actual or threatened aggression to dissuade interlopers from mate-poaching attempts. Yet other tactics are directed toward one's mate. Some of these inflict costs (e.g., "she hit him when she caught him flirting with someone else"), whereas others bestow benefits ("he was helpful when she really needed it").

Some of these benefit-bestowing tactics may be more successful for decreasing the threat of emotional than sexual infidelity, or vice versa. For example, if male provisioning of resources was an important benefit that shaped female long-term mating strategies (e.g., see Marlowe, 2003) and the emotional attachment associated with such pair-bonds (see Belk & Coon, 1993; Lawler et al., 1994; see also Balconi & Fronda, 2020), then tactics that deliver material resources may be an effective means for males to address concerns about the threat of *emotional* infidelity. On the other hand, if a principal function of extra-pair copulations for females is to obtain "good genes" for their offspring (Gangestad & Simpson, 2000), then behaviors by the female's partner that deliver material resources (but not genetic resources) may be less effective for thwarting the threat of *sexual* infidelity. Whether males are more likely to provision resources in response to the threat of emotional infidelity than in response to the threat of sexual infidelity, and whether resource provisioning is more effective at thwarting the threat of a female's emotional (relative to sexual) infidelity are two research questions that have yet to be investigated.

The efficacy of some of these tactics also depends on characteristics of the rival. For example, behaviors such as "Threatened to hit a man who was making moves on my partner" or "Picked a fight with a man who was interested in my partner" may extinguish a mate poaching threat when one is more physically
p. 400 formidable than the interloper. However, if the opposite ↳ is true, then such behaviors may be ineffective and may even exacerbate the threat: a public defeat in intrasexual competition may decrease perceptions of one's desirability as a mate, and the interloper's victory may increase perceptions of their desirability (Sell, Lukaszewski, & Townsley, 2017).

These considerations reflect a key principle: a behavioral response to a problem will only be successful to the extent that the response is tailored to the specific instantiation of the problem (for in-depth discussions of why context is crucial in evolutionary psychology, see Al-Shawaf et al., 2019; Lewis, Al-Shawaf, Thompson, & Buss, 2021; Lewis & Buss, 2021). This principle reinforces the overarching hypothesis that the jealousy program should seek information about the specific features of the infidelity threat that it faces (e.g., rival characteristics, circumstances): it needs this information in order to effectively solve the relevant problem.

This principle also underscores the point that jealousy must operate according to *specific* input-output mappings. Abundant research has addressed the *general and abstract* processing structure of jealousy: it activates in response to a broad class of situational inputs (i.e., cues to infidelity). However, for jealousy to effectively thwart the threat of infidelity—which, as discussed above, comes in many different forms, with

diverse causes and sources—it must selectively deploy its different behavioral outputs in precise functional alignment with specific inputs.

A key next step will therefore be to use existing resources, such as taxonomies of jealousy's inputs (e.g., "Cues to Infidelity" from Shackelford & Buss, 1997b) and outputs (e.g., the MRI; Buss, 1988), to investigate how jealousy maps *specific* outputs onto *specific* inputs. One way to translate these existing resources into these specific mappings is through detailed task analyses of different forms of the broad adaptive problem of infidelity threat. Researchers should consider how the efficacy of different mate retention tactics depends on the specific form of the infidelity threat, such as its source (e.g., endogenous vs. exogenous to the relationship), the surrounding circumstances (e.g., if the source is exogenous, the specific environments in which a would-be mate poacher is likely to pose a threat), and the characteristics of the rival. These contextual features, which can vary widely across different instantiations of infidelity threat, can profoundly impact the efficacy of distinct mate retention tactics. We should therefore expect the jealousy program to deploy specific tactics in functional alignment with these specific features of the threat.

Although a growing body of research has examined the differential deployment of mate retention tactics as a function of individual differences such as sex (e.g., Buss & Shackelford, 1997; see also Atari, Barbaro, Shackelford, & Chegeni, 2017; Chaudhary et al., 2018), personality (e.g., Atari, Barbaro, Sela, et al., 2017; McKibbin et al., 2014), attachment orientation (Barbaro et al., 2021; Nascimento et al., 2021; see also Barbaro et al., 2016; Barbaro et al., 2019), and mate value (Miner, Starratt, & Shackelford, 2009; see also Miner, Shackelford, & Starratt, 2009), as well as the "type" of jealousy experienced (see Davis et al., 2018) and sperm competition risk (Goetz et al., 2005), we are aware of only one study—an unpublished dissertation by Lewis (2013)—that has examined the differential deployment of mate retention tactics specifically as a function of distinct forms of infidelity threat.

Reiterating some of Buss and Shackelford's (1997) logic, Lewis argued that a male being mated to a female who is higher in mate value than he is poses a looming infidelity threat. Lewis (2013) also reasoned that being low in mate value poses an *independent* source of infidelity threat above and beyond any such mate value discrepancy (see also Miner, Shackelford, & Starratt, 2009; Miner, Starratt, & Shackelford, 2009). More precisely, these two cues—(1) a male's mate value and (2) the discrepancy between his mate value and that of his partner—predict distinct forms of relationship threat. The genetic benefits that a female could
p. 401 reap from ↳ a sexual affair with a male of high mate value depend on the mate value of her current partner, *independent* of any mate value discrepancy between her and her current partner. However, the female's ability to secure a different long-term partner who is higher in mate value than her current partner likely *does* depend on this mate value discrepancy; if a female is mated to a male lower in mate value than she is, it should be easier for her to secure a new long-term partner higher in mate value than her current partner. Consequently, her partner's mate value may more strongly predict the threat of her sexual infidelity than the threat of her long-term defection, whereas the discrepancy between her mate value and her partner's mate value may be a stronger predictor (than his mate value alone) of the threat of her long-term defection.

Lewis (2013) found distinct patterns of mate retention behavior among men that appear functionally tailored to these different threats. When a male is mated to a female who is higher in mate value than he is, provisioning (non-genetic) resources could be effective for increasing her perceptions of the value of the present relationship, and thereby reduce her likelihood of her terminating the long-term relationship or defecting to another long-term mate. Consistent with this, Lewis (2013) found that males mated to females higher in mate value than themselves were more likely to deploy benefit-provisioning mate retention tactics, such as *love and care* and *resource display* (e.g., "spent a lot of money on my partner").

However, if an important function of extra-pair copulations for females is to secure genetic benefits, then males' provisioning of non-genetic resources may not successfully thwart the threat of sexual infidelity. To the extent that men's (low) mate value is a predictor specifically of his partner's sexual infidelity (and less

so of her long-term abandonment), then we might expect low-mate-value men to engage in a subset of mate retention tactics that appear designed specifically to thwart infidelity threat. Consistent with this hypothesis, Lewis (2013) found that men of lower mate value more frequently engaged in tactics such as *punish mate's infidelity threat* as well as *vigilance* and *monopolization of mate's time*—tactics that may reduce or eliminate a mate's ability to consort with potential affair partners. These findings point to the conclusions that, among men, the jealousy system (a) processes, as distinct cues, both low mate value and mate value discrepancies, and (b) differentially responds to these predictors of infidelity and abandonment threat through functionally tailored tactics. Overall, mate value discrepancies predicted the deployment of 12 distinct tactics (11 of which were *not* predicted by low mate value among men), and low mate value among men predicted their deployment of 4 anti-infidelity tactics (only 1 of which was predicted by mate value discrepancies).

This example illustrates the utility of (1) considering how different cues may predict distinct forms of relationship threat, (2) conducting task analyses of these distinct forms of threat, and (3) carrying out cost-benefit analyses of jealousy's distinct behavioral outputs *in the context of those different forms of threat* in order to identify the specific tactics that we should expect the jealousy program to deploy. We hope that research is soon characterized by this greater specificity about jealousy's information-processing and behavioral coordination architecture; the identification of specific input-output mappings is a key part of a mature and comprehensive understanding of an emotion program (see Sznycer & Cohen, 2021a; see also Al-Shawaf et al., 2016). We anticipate that researchers will be able to make rapid progress toward identifying these input-output mappings by carrying out these analyses of specific forms of threat and making good use of the extensive inventories of specific inputs and outputs already available, such as Shackelford and Buss's (1997b) "Cues to Infidelity," Buss's (1988) Mate Retention Inventory, and Pham, Barbaro, and Shackelford's (2015) complementary Coalitional Mate Retention Inventory.

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Future Directions

Step 4: Deactivate When the Threat Has Been Resolved

We should expect jealousy to be characterized by design features that interrupt its operation after the threat of infidelity has been resolved (see Sznycer, 2019; see also Al-Shawaf, 2016b; Al-Shawaf et al., 2016; for a parallel set of deactivation or "offlining" hypotheses about hunger and sexual arousal, respectively). These "switching off" design features have been documented for emotions such as anger (Sell, Sznycer, et al., 2017), but little is known about what turns the jealousy program off—rendering this a key future research direction.

There are two very different ways in which infidelity threat can resolve: the threat may be successfully thwarted, or the threat may translate into actual infidelity. We should expect jealousy to respond differently to these distinct outcomes, including in ways that might not initially be obvious.

When the Threat Is Successfully Thwarted

When the threat is successfully thwarted, the jealousy program may cease its operation. This "turning off" may manifest in multiple ways. One way is ceased information search. Another is the decreased deployment of mate retention tactics designed specifically to address infidelity threat (e.g., *punish mate's infidelity threat*). Yet another way is the reduction of some of the negative subjective states that jealousy mobilizes.

Consistent with the last hypothesis that the deactivation of jealousy may manifest in a reduction of negative affect, Schützwohl (2008) found that both males and females indicated being relieved to learn that their

partners had not been unfaithful. Moreover, consistent with known sex differences in the operation of jealousy, Schützwohl found that (1) males, compared to females, indicated greater relief in response to learning that their mate had not been sexually unfaithful, whereas (2) females indicated greater relief in response to learning that their mate had not been emotionally unfaithful than in response to learning that their partner had not been sexually unfaithful.

Schützwohl (2008) did not find support, however, for the prediction that the magnitude of relief experienced would track the degree of infidelity threat, which was based on the idea that the activation of jealousy is proportional to the degree of threat. We think this unexpected finding might reflect an overlooked design feature of jealousy: at least under some circumstances, the jealousy program *may actually be designed to turn off when infidelity becomes certain*.

When Infidelity Is Certain

If the jealousy program is designed to prevent infidelity, then when infidelity becomes certain, we might expect jealousy to operate differently between (1) people who intend to terminate the relationship in response to their partner's infidelity and (2) those who seek to maintain the relationship despite their partner's infidelity. This is because the threat of the partner's further unfaithful behavior remains an adaptive problem for those who seek to maintain the relationship, but not for those who seek to break up.

Among those who seek to stay in the relationship, the jealousy program may increase its sensitivity to infidelity cues. This increased sensitivity could include activating in response to a larger range of cues, including those with low predictive validities, as well as producing stronger responses to cues that have moderate predictive validities. The jealousy program may also deploy more mate retention tactics, in particular tactics geared toward thwarting (further) infidelity, such as *vigilance* and *monopolization of mate's time*.

On the other hand, when infidelity is certain and the individual intends to terminate the relationship, the
p. 403 continued operation of jealousy is likely to carry costs but no compensatory ↳ benefits—and may therefore be designed to turn off. This may help explain an unpredicted finding in Schützwohl (2008): people indicate *greater* relief when their partner's "merely suspected" infidelity is disconfirmed than when "virtually certain" infidelity is disconfirmed. In other words, being uncertain about—but suspecting—a partner's infidelity may be associated with greater activation of the jealousy program than when one is almost certain that infidelity has occurred. This is consistent with the hypothesis that the jealousy program is (1) designed to remain active when the benefits of doing so (i.e., *preventing* infidelity) exceed the costs of its operation, and (2) designed to turn off when those costs exceed the benefits, which is precisely what occurs when one intends to terminate the relationship and the partner's further infidelity is thus no longer an adaptive problem.

Lewis and colleagues (Lewis, 2013; Lewis, Lukaszewski, et al., 2023) also found evidence consistent with this hypothesis. Lewis (2013) presented participants with five scenarios of increasing infidelity threat and asked them to describe what they would think, feel, say, and do in response to each scenario. Lewis and colleagues then presented these written responses to third parties, who rated the level of jealousy exhibited in each response. Across the first four scenarios, people's jealousy increased in proportion to the likelihood of infidelity. However, this increasing activation of the jealousy program in proportion to the likelihood of infidelity *disappeared when infidelity became certain* in the fifth scenario (Lewis, Lukaszewski, et al., 2023).

When Infidelity Is Certain: Terminate the Relationship, or Attempt to Restore It?

Although Schützwohl (2008) and Lewis and colleagues (Lewis, 2013; Lewis, Lukaszewski, et al., 2023; see also Lukaszewski et al., 2020) provide preliminary evidence suggesting that jealousy may deactivate when infidelity becomes certain, a key shortcoming of their work is that they do not have any measures of participants' intentions to maintain versus terminate the relationship. Capturing this information is important for testing the hypothesized design features of jealousy discussed here. Among people who intend to terminate the relationship, we might expect decreased activation of jealousy, whereas we might expect the opposite among people who seek to restore the relationship.

Moreover, the algorithms by which the jealousy program makes this decision—to terminate the relationship or attempt to reinstate it after a partner's infidelity—are an important but relatively unexplored facet of jealousy's information-processing architecture. Shackelford and colleagues (e.g., Shackelford & Buss, 1997a; Shackelford et al., 2002) made important initial strides two decades ago, but work has been sparse since then (e.g., 16 years later, Bendixen et al., 2018, attempted a replication study). Shackelford et al. (2002) provided evidence suggesting that the inputs the jealousy program uses to make the "terminate or reinstate" decision include the *type* of infidelity committed, in interaction with the sex of the decision-maker. Consistent with study hypotheses, Shackelford and colleagues (2002) found that more men (65%) than women (52%) reported that sexual infidelity would be more difficult to forgive than emotional infidelity, and more men (55%) than women (42%) reported a greater likelihood of terminating the relationship after sexual than emotional infidelity. The authors also found that, if the partner had been *both* sexually and emotionally unfaithful, more men (58%) than women (41%) reported that the sexual aspect of the infidelity would be more difficult to forgive.

We also might expect the cognitive architecture responsible for the decision to terminate or attempt to restore the relationship to process the relative mate values of the decision-maker and their unfaithful partner. When one is the lower-mate-value partner in the relationship, one has a lower likelihood of being able to secure another partner as high in mate value as the current partner, compared to when one is the
p. 404 higher-mate-value partner. Consequently, we ↳ might expect the jealousy program to process the mate value discrepancy within the dyad as input when determining whether to terminate the relationship or attempt to reinstate it. If this hypothesis is correct, then people should be less likely to terminate a relationship with an unfaithful partner when that partner is higher in mate value than they are, compared to when the partner is equal or lower in mate value. Consistent with this, women married to men who are lower in mate value than themselves report being more likely to seek divorce in response to their husband's unfaithfulness (Shackelford & Buss, 1997a).

Research by Phillips (2010) provides evidence that (1) further suggests that mate value discrepancies are an important input into the algorithms responsible for the terminate-or-reinstate decision, and (2) is consistent with the hypothesis that the jealousy program deactivates when the decision to terminate is made. Phillips (2010) asked people to indicate the extent to which they would experience anxiety and insecurity if they discovered that their partner had been sexually unfaithful. If the hypotheses discussed here are correct—that jealousy is designed to (1) take, as input, mate value discrepancies when making the terminate-or-reinstate decision, and (2) deactivate when the choice is made to terminate—then we should expect jealousy to be more likely to deactivate among people who are higher in mate value than their unfaithful partners. Phillips's (2010) observations are consistent with this hypothesis: people who perceived themselves as higher in mate value than their partner scored lower on a composite measure of anxiety and insecurity in response to their partner's infidelity.

Collectively, these findings suggest that mate value discrepancies and the type of infidelity, in interaction with the sex of the decision-maker, are inputs that the jealousy program processes in the context of the decision to terminate or restore the relationship after a partner's infidelity. We anticipate that jealousy is

sensitive to numerous other inputs linked to the costs and benefits of terminating versus reinstating the relationship. These include one's perceptions of the likelihood of violent retaliatory aggression if one terminates the relationship; one's access to allies who could offer protection against such aggression; the availability and mate values of potential mates in the local mating pool; and whether one shares offspring with the unfaithful partner (e.g., see Betzig, 1989; Buckle et al., 1996).

Jealousy versus Anger

Phillips (2010) also indirectly points toward the importance of more clearly differentiating between the distinct psychological architectures of jealousy and anger, which frequently co-activate. The jealousy program is a hypothesized adaptation designed to activate in response to infidelity threat, whereas the anger program is a hypothesized adaptation designed to activate in response to another person placing too little value on one's welfare. On this view, jealousy and anger are distinct programs designed to deal with different adaptive problems. However, the cues that trigger the jealousy program should frequently trigger the anger program as well. For example, behaviors by one's mate that suggest that one's mate is seeking extra-pair mating opportunities are cues to infidelity threat—which should activate the jealousy program—*and* they indicate that one's mate places too little value on one's welfare—which should activate the anger program (see Sell, 2005, 2011; Sell, Sznycer, et al., 2017; see also Lewis, Lukaszewski, et al., 2023; Lukaszewski et al., 2020). Consequently, we should expect jealousy and anger to frequently co-activate.

This frequent co-activation makes it difficult to determine how best to classify behavioral responses to such scenarios. For example, it is not entirely clear whether behaviors such as "She became angry when her partner flirted too much" (see Buss, 1988) are best classified as outputs of jealousy or anger. Moreover, it is
p. 405 plausible that one of the broad classes of output from the ↳ jealousy program is *to activate the anger program.* These and other complications can make it challenging to disentangle these emotion programs under certain circumstances.

Nonetheless, we think this is an important task for future research, and one that will pay off. Phillips (2010) had participants report how much anxiety, insecurity, hostility, and anger they would experience in response to their partner's sexual infidelity. Phillips composited participants' responses to these questions to create measures of "insecurity" (anxiety, insecurity) and "indignation" (anger, hostility). "Insecurity" appears to capture the outputs of the jealousy program, whereas "indignation" appears to reflect the outputs of the anger program. People higher in mate value than their unfaithful partners reported *lower* levels of insecurity, consistent with the ideas that (1) such mate value discrepancies predict the decision to terminate the relationship, and (2) once the terminate decision is made, this turns off the jealousy program. However, and by contrast, people higher in mate value indicated that they would experience *more* indignation. This is consistent with the hypothesis that individuals who have higher bargaining power expect their welfare to be valued more, thereby have a lower threshold for the activation of the anger program, and, consequently, experience more anger (Sell et al., 2009). In short, Phillips's (2010) work provides preliminary evidence that the (de)activation of the jealousy program is not inextricably tied to the (de)activation of the anger program. This suggests that, despite the frequent co-activation of jealousy and anger, these two emotions have distinct information-processing architectures that differentially respond to distinct inputs.

Lewis and colleagues (Lewis, 2013; Lewis, Lukaszewski, et al., 2023; see also Lukaszewski et al., 2020) found further evidence suggesting that jealousy and anger are distinct emotion programs that are activated by at least partially non-overlapping classes of inputs. In their research, Lewis and colleagues presented mated individuals with five different scenarios that exhibited progressively increasing levels of infidelity threat. The fifth scenario, which described certain infidelity, provided a key test of the discriminant activation of anger and jealousy. Because certain infidelity unequivocally reveals the devaluation of ego by ego's mate,

the fifth scenario should have resulted in the *greatest* anger. However, if as hypothesized in this chapter, certain infidelity *deactivates* the jealousy program (at least in some individuals in some contexts; see above), then jealousy should have increased progressively across the scenarios *until* the fifth scenario. In precise alignment with this reasoning, people's anger increased across the scenarios and was highest in the certain infidelity condition, whereas jealousy increased across the infidelity scenarios *until* the fifth scenario—at which point it did not increase. Although these findings are a minority in a broader literature that has frequently documented the co-activation of jealousy and anger, they highlight the important future endeavor of disentangling the information-processing architectures of these different emotions.

Jealousy across Relationship Types: Distinct Adaptive Problems and Functions

Much of this chapter has emphasized "zooming in" on jealousy in mating relationships: important progress can be made through future work that is *more specific*—about the instantiation of infidelity threat, including its type and source; about the probabilistic costs and benefits of distinct mate-retention tactics, including variation in these costs and benefits across different instantiations of infidelity threat; about individual difference and contextual variables likely to influence the decision to terminate or attempt to restore a relationship upon discovering infidelity; and so on. Indeed, greater specificity will be fundamental to a more sophisticated and comprehensive understanding of how jealousy works.

Another key future direction will be to "zoom out" and consider jealousy at a level of *greater abstraction*—as an emotion program that responds to "a threat to a valued social relationship" (Buss, 2013, p. 155, citing
p. 406 Daly et al., 1982). This high level of abstraction usefully ↳ highlights that jealousy should not be restricted to mating; it should also operate in other types of relationships. Indeed, there is evidence of jealousy in friendships (e.g., Krems et al., 2021) and other relationship types (e.g., among siblings; see Hart, 2018).

Although this "zooming out" from mating relationships usefully guides attention to jealousy in other relationship types, characterizing jealousy at this high level of abstraction could also carry pitfalls that should be avoided. For example, this way of characterizing jealousy implicitly suggests that the same emotion program operates in both mating and non-mating relationships. It might therefore be tempting to attempt to empirically address questions such as "Are friendship jealousy and mating jealousy the same or different adaptations?"

We suggest that such questions may not be well-formulated, and that researchers should direct their attention in a different manner. Because mechanisms (like jealousy) are defined by their function, functions are defined by the problem they solve, and problems can be described at varying levels of abstraction, questions about the *number* of mechanisms are often unhelpful, because the answer depends on the level of abstraction or specificity at which adaptive problems are being described (for a general discussion of this issue, see Pietraszewski & Wertz, 2021; see also Shackelford, 2003). Rather, as we have emphasized throughout this chapter, researchers should focus on precisely characterizing specific adaptive problems; identifying, a priori, information-processing and behavior-coordinating design features capable of economically and efficiently solving those problems (Al-Shawaf et al., 2021); and testing for evidence of these hypothesized design features.

On this view, the most relevant and most interesting question in the context of jealousy in mating relationships versus jealousy in friendships is not whether they are different adaptations. Rather, it is: What important differences exist between the adaptive problems of *threat to a mateship* and *threat to a friendship*? And how might cognitive and behavioral solutions to these distinct problems differ?

Answering these questions requires attending more deeply to the concept of *infidelity*. This concept is central to the literature on jealousy in mating relationships, but is virtually absent from discussions of friendship jealousy. On the one hand, it is possible that the concept of infidelity does not pertain to

friendships. Indeed, if a necessary precondition for invoking the concept of infidelity is an implicit social contract involving *exclusive* access to the other person and their resources—and one of the defining features of a friendship is *non*-exclusivity—then the concept of infidelity might simply not apply to friendships. On the other hand, people can have very pronounced emotional responses when a friend's resources are diverted to a third party (e.g., see Krems et al., 2021). This suggests that although the implicit social contract associated with friendship may not involve "infidelity" in the sense above, there *is* an implicit social contract, and violations of that contract activate jealousy. If jealousy is designed to operate across multiple relationship types, but its operation varies as a function of the implicit social contracts entailed by different relationship types, then more precisely characterizing these implicit social contracts is a key future direction for research on jealousy.

Little appears to be known about the implicit social contract of friendship, and even less is known about whether there are distinct social contracts associated with different types of friendship. For example, a "best" friend may not simply be the friend to whom someone is closest. Instead, a "best" friendship may be characterized by an implicit social contract that is qualitatively different from other friendships. For example, if ego's friend shared their resources with others but did not also share them with ego, that might violate a best friendship but not necessarily other friendship types. That is, best friendship might be characterized by an implicit rule of *obligatory inclusion* that is absent from the implicit contracts of other friendship types. Another rule that might categorically differentiate best friendship from other friendships
p. 407 is ↳ the implicit stipulation that ego's best friend will ally with ego in any antagonistic encounter between ego and a third party (see DeScioli & Kurzban, 2009; Shaw et al., 2017). Researchers can pit these alternative views—(1) a best friend is merely the friend to whom one is closest, and (2) best friendship is a categorically different and special relationship type—against each other by identifying and testing their divergent predictions. For example, if best friendship is *not* a categorically different relationship type, then all individuals with friends should have report having a best friend. However, if best friendship is defined by a distinct social contract, then only those individuals who have a friend who meets the terms of that contract should report having a best friend. This is a key distinction to be tested in future research.

If the implicit terms of the social contract of best friendship differ from those of other friendships, then we might expect jealousy to operate categorically differently in the context of best friendship compared to other friendships. For example, if the first author of this chapter got married and invited the third author to his wedding—but did not invite the second author—that could violate the implicit social contract between the first and second authors, thereby activating the latter's jealousy program—whereas if the first author invited the second author to his wedding but not the third author, that might *not* violate the implicit social contract between the first and third authors and consequently *not* activate the third author's jealousy program. Future research on friendship jealousy could profit from identifying precisely what terms are included in the implicit social contracts of friendships, including determining whether the terms implicit to friendship and best friendship differ. This will enable researchers to more precisely test how jealousy works in the context of friendship.

Similarly, research is needed to better establish precisely what terms are stipulated by different kinds of *mating* relationships, as the jealousy program may operate differently across these relationship types. For example, what constitutes infidelity in long-term monogamous relationships differs from what qualifies as infidelity in consensually non-monogamous (CNM) relationships. Contrary to misconceptions, "cheating" can and does occur in CNM relationships. It may not be defined by exclusivity, but rather by whether the partner was informed of the third party, the degree of emotional connection with the third party, or other terms, some of which may be implicit and others of which may be explicit (see Moors et al., 2017; see also Mogilski et al., 2019). Research on differences in jealousy between monogamous and CNM relationships is relatively new (e.g., Mogilski et al., 2019; Valentova et al., 2020), and we eagerly await new research into how jealousy might operate differently across these different types of long-term mating relationships.

Similarly, relatively little is known about the operation of jealousy in short-term, uncommitted relationships. Again, the definition of "infidelity" in the context of long-term monogamous relationships presumably does not apply to these relationships. However, given that many important fitness-relevant benefits can be derived from short-term relationships, we should expect jealousy to operate to protect such relationships when they are threatened by third parties. For example, the resources that one derives from a "friend with benefits" (FWB) relationship would be threatened if one's FWB formed a new long-term, monogamous relationship; the FWB may cease to provide those "benefits" (e.g., sex) because doing so would violate their new, sexually exclusive relationship (see Lewis et al., 2012, for a discussion of the relationship between people's relationship status and their openness to mating with their friends; see also Lewis et al., 2011). Consequently, people may attempt to impede the formation of long-term relationships between their FWBs and third parties. This may include the deployment of mate-retention tactics such as *derogation of competitors* (Buss, 1988). However, some mate-retention tactics, such as *physical signals of possession*, might actively violate the FWB relationship. Consequently, we might expect the operation of
p. 408 jealousy in FWB relationships ↳ to be characterized by a distinct profile of mate-retention tactics compared to long-term relationships. Future research should be able to address these questions through a combination of qualitative approaches (e.g., act nomination procedures in which people describe what they do to maintain and protect their FWB relationships) and quantitative analyses (e.g., testing for differences in the relative frequencies at which distinct mate-retention tactics are deployed in FWB relationships versus long-term, monogamous mateships).

More broadly, we eagerly await further research testing how jealousy activates and manifests in uncommitted mating relationships. The lack of commitment that defines these relationships changes the costs and benefits of jealousy in several ways. First, on average, the loss of a short-term mate is less costly than the loss of a long-term mate. Second, by definition, short-term mateships are not characterized by long-term investment, so the risk of unwittingly investing in somebody else's offspring is largely nullified. Because this adaptive problem of being cuckolded is specific to males, the absence of this adaptive problem from short-term relationships may attenuate some of the sex differences in jealousy observed in long-term, monogamous relationships. Third, the activation of jealousy to protect against relationship threats consumes time and resources. Jealousy therefore entails costs, including opportunity costs. These costs may be higher among short-term-oriented individuals, as they could instead allocate those resources toward alternative short-term mating efforts. The benefits of protecting against third-party threats may also be minimal, given the often transient nature of the relationship in the first place. In short, the costs of jealousy in uncommitted mating may be higher, and the benefits lower, than in exclusive long-term mateships. Based on this, we might expect to observe lower levels of jealousy (1) in uncommitted relationships relative to committed monogamous relationships, and (2) among people oriented toward short-term mating. As an alternative to the latter hypothesis, people oriented toward uncommitted mating may not exhibit less jealousy overall, but may instead exhibit a distinct profile of mate-retention behavior. Specifically, they may be less likely to engage in mate-retention tactics that require their time and physical presence, and more likely to engage in tactics that can thwart threats without requiring much investment, such as sexual inducements (Buss, 1988).

We are not aware of much research testing these or other theoretically anchored hypotheses about the differential operation of the jealousy program as a function of mating strategy. Of the work that has investigated the relationship between jealousy and sociosexual orientation, much of its focus has been on demonstrating that sex differences in jealousy are robust after controlling for this individual difference variable (e.g., Brase et al., 2014; Bendixen et al., 2015). Moreover, existing studies have produced inconsistent results with respect to the relationship between mating strategy and jealousy. Treger and Sprecher (2011) found that an orientation toward short-term mating was associated with *greater* distress to infidelity, whereas Russell and Harton (2005) found no relationship between sociosexual orientation and jealousy. We hope to see future hypothesis-driven investigations into the relationship between mating

strategy and the operation of the jealousy program, including research that tests for individual differences in the deployment of specific mate-retention tactics as a function of sociosexual orientation (see also Al-Shawaf, Lewis, et al., 2015; Al-Shawaf, Lewis, & Buss, 2015, for examples of mating strategy-linked differences in the operation of an emotion). More broadly, we think a key future direction for jealousy research is a growth in focus on the myriad types of mating relationships—not just long-term, monogamous relationships.

Quantitative Variation in the Jealousy Program

The idea that jealousy may operate differently across individuals as a function of their mating strategy
p. 409 points toward the broader question of variation in the parameterization of the jealousy ↳ program. Potential proximate causes for such variation include genetic variation, stable situational evocation, and developmental calibration, the latter two of which may produce both between-individual differences and within-individual shifts (see Lewis et al., 2020; see also Lewis, 2015; Lewis et al., 2018; Lukaszewski et al., 2020). For example, people in environments characterized by many mating rivals (e.g., females in an environment with a female-biased operational sex ratio) may have lower thresholds for the activation of jealousy, compared to their counterparts in environments with an abundance of available mates (e.g., females in an environment with a male-biased operational sex ratio). There are also several reasons that individuals may exhibit shifts in the parameterization of the jealousy program. For example, when a person's mate commits infidelity, the program may respond by lowering its threshold for activation, and this effect may even persist into future relationships with other partners (see Burchell & Ward, 2011; Tagler, 2010; Zandbergen & Brown, 2015). Additionally, when one partner is more dependent on the other than usual (e.g., he is ill or injured, she is pregnant or has just given birth) (see Marlowe, 2003), they may exhibit heightened sensitivity (e.g., lower thresholds for jealousy activation). We eagerly await future research testing these and other hypotheses about between- and within-individual variation in jealousy.

Conclusion

Much is already known about jealousy, but a great deal of work remains in order to achieve a comprehensive understanding of this emotion. An important goal should be to identify jealousy's information-processing and behavior-coordinating design features at different stages of addressing the problem of relationship threat. Gaps in current knowledge exist with respect to (1) the information-acquisition features of jealousy in the early stages of detecting and appraising the threat, (2) the differential deployment of distinct mate-retention tactics as a function of distinct forms of threat, and (3) the information-processing architecture of the algorithms involved in the decision to terminate or attempt to restore a relationship after infidelity is discovered.

Major strides have been made toward understanding how jealousy works in *long-term monogamous mateships*, but much less is known about jealousy in other mating relationships (e.g., "friends with benefits" relationships, CNM relationships). Even more broadly, future work is needed to better understand how jealousy operates across other relationship types beyond mating, including friendships and family relationships (e.g., competition among siblings over parental resources).

Finally, there is robust evidence of sex differences in jealousy, but sex differences are just a small subset of between-individual differences. Many individual difference variables, such as sociosexual orientation, may shift the costs and benefits of jealousy. If so, then we might expect to observe variation in the jealousy program's parameterization (e.g., activation threshold) and behavioral outputs (e.g., specific mate-retention tactics) as a function of these individual difference variables. The same logic applies to *within*-individual changes in jealousy over time. Changing environments, critical life events, and changes in the

adaptive problems that individuals face at different stages of the lifespan may be associated with ongoing developmental calibration of the jealousy system.

In short, much is known about jealousy, and much remains to be discovered. We hope this chapter makes a modest contribution toward the continued progress of research on this important human emotion. If the progress made in the first decades of its investigation is any indication of the progress that will be made in the forthcoming years, then we can expect many exciting new developments and discoveries to come.

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