Fooled around and fell in love: The role of sex in adult romantic attachment formation

Vivian Zayas  
Department of Psychology, Cornell University

Sarah Merrill  
Department of Human Development, Cornell University

Cindy Hazan  
Department of Human Development, Cornell University

Correspondence to:  
Vivian Zayas  
Department of Psychology  
Cornell University  
238 Uris Hall  
Ithaca, NY 14853-7601  
Email: vz29@cornell.edu

Abstract

Romantic partners typically serve as attachment figures as well as sexual partners. But, surprisingly, sex research and adult attachment research have progressed independently. Consequently, little is known about how the sexual mating system affects adult attachment formation. In the present chapter, we examine this issue. We propose that the neural and physiological systems operating during sexual interactions overlap significantly with those underlying attachment bonds. As a result, sexual encounters may promote physiological and endocrinological states associated with feelings of attachment security. If such interactions are repeated over time with the same partner, the systems become conditioned, and this, in turn, promotes the formation of a pair bond.
Introduction

A central proposition of Bowlby’s ethological attachment theory is that attachment is integral to human behavior throughout the lifespan, “from the cradle to the grave. (Bowlby, 1979, p. 129)” The theory provides a comprehensive and detailed account of the evolutionary roots, ontogeny, and developmental sequelae of infant-caregiver bonds. Although in adulthood individuals may be attached to multiple individuals (e.g., parents, friends, siblings; Baldwin, Keelan, Fehr, Enns, & Koh-Rangarajoo, 1996), the theory posits that pair bonds, or relationships between romantic partners, are the prototypical instantiation of attachment in adulthood.

Whether in infancy or adulthood, the features that distinguish attachment bonds from other types of social ties are the same. Specifically, attachments are characterized by proximity seeking/maintenance (the tendency to stay in touch), safe haven (the tendency to turn to attachment figures for comfort or reassurance), separation distress (the tendency to resist and be upset by unwanted or prolonged separations), and secure base (the tendency to explore because one is emboldened by knowing that support is available when needed).

Despite these similarities in attachment relationships, infant/caregiver relationships and adult romantic relationships differ in important ways. In particular, infant-caregiver relationships are typically complementary. That is, infants seek security and comfort from, but do not intentionally provide security or comfort to, attachment figures. In contrast, adult romantic relationships are reciprocal. Partners serve as both recipients and providers of security and comfort. In addition, and most relevant to the present chapter, adult romantic relationships are typically sexual in nature. In other
words, adult attachment bonds involve the integration of three distinct behavioral systems: attachment, caregiving, and sexual mating.

It is thus somewhat surprising how very little adult attachment research has addressed the sexual mating system. Indeed, the fields of sex research and adult attachment research have progressed quite independently. Although sex can be an entirely casual or even solo activity, most sexual interactions occur within the context of an ongoing romantic relationship (Impett, Muise, & Peragine, 2013). The specific question that we address in the present chapter is what role sex might play in the formation of an adult attachment bond. For the purposes of this chapter, we are defining sexual interactions as any behaviors that are motivated by an urge to gratify sexual motivation, including, but not limited to, sexual touch, sexual kissing, rubbing or stimulation of the genitals, nipples, or other erogenous zones, cunnilingus, fellatio, and vaginal and anal penetration.

The process by which two individuals go from being relative strangers to having developed a full-fledged attachment bond is still not well understood (Zayas & Hazan, 2014). Nonetheless, there is good reason to think about the role of sex in adult attachment. We propose that the sexual mating system is not only involved in sparking initial attraction and interest in, and promoting proximity towards one person (over all other potential partners). But, also, critically, once a relationship is underway, repeated sexual activity with the same partner is expected to condition basic physiological and endocrinological systems, which, in turn, distinguishes this relationship from others and serve to promote a pair bond.

In particular, in initial stages of relationship formation, the sexual mating system
is involved in attraction, and this has important implications for attachment formation. As noted above, a defining feature of attachment is proximity seeking. Humans are an altricial species, and offspring are born in a state of extreme immaturity and dependence. As a result of evolutionary processes, human infants are born with an attachment system that promotes seeking and maintaining proximity to important others (adult caregivers) who are able to provide protection, support, and comfort (Bowlby, 1982). But what motivates mature members of the human species to seek proximity to each other? One major force is sexual attraction. Infants are drawn to conspecifics in early life because their very lives depend on seeking protection and care, but adults are motivated to seek proximity to and contact with others for reasons of sexual interest. By fostering physical intimacy and triggering associated neurochemical systems, this initial sexual attraction sets the stage for potentially developing a full-fledged attachment relationship.

Moreover, as the relationship is underway, the sexual mating system plays a key role in transforming the relationship from one of simple attraction between two strangers to one between two attached partners. In this respect, there are two issues of central importance. One, although the sexual mating and attachment systems are distinct and independent and have evolved to serve different functions (Diamond, 2004), there is still considerable overlap in basic structures of the two systems (Diamond & Dickenson, 2012) The second is that having sex repeatedly with the same person engages these specific (and overlapping) brain structures and activates specific neurochemical systems that facilitate the formation of an adult attachment bond. In what follows we focus specifically on the dopaminergic/reward system and the oxytocinergic/opioid arousal-relief systems. The take-home message of the extant findings, which are discussed below,
is that through repeated sexual exchanges with the same person these systems become conditioned. The effect of the conditioning is that he or she, whether physically present or just mentally conjured, can automatically activate these systems. This process of the conditioning of specific reward and relief neural systems, in our view, is the core of adult attachment formation.

First, a few caveats. Exactly how sex figures into adult attachment is complicated, and likely varies as a function of multiple individual and group and possibly gender factors. We intentionally suspend commentary on these possible variations (which we return to at the end of the chapter) in order to focus attention on a set of processes and mechanisms that have yet to be articulated or explored in the attachment literature and that hold promise for shedding light on the role of sexual intercourse in the formation of adult attachment bonds.

The chapter is organized as follows: We begin by providing a brief summary of the behavioral, psychological, physiological, and neural correlates assumed to characterize an adult attachment bond. We then describe the basic physiological and neural processes involved in sexual intercourse and highlight systems that overlap with the attachment system. We conclude by raising many interesting, but as yet unanswered, questions with regard to personal and situational moderators of the purported model that we hope will fuel future investigations.

The Adult Attachment System

In adulthood, long-term pair bonds confer a number of psychological and physical benefits. Partners are capable of regulating each other’s physiological systems, daily mood and affective states, as well as eating and sleeping patterns (Selcuk, Zayas, &
Hazan, 2010). There is a rich literature delineating the precise psychological and neural systems that underlie adult pair bonds and give rise to attachment-related behaviors (proximity maintenance, safe haven, secure base, and separation distress) (see Mikulincer & Shaver, 2007, for review).

These manifestations of adult pair bonds in terms of physiology, emotion, and behavior are assumed to reflect the functioning of mental representations, or internal working models. A core idea of attachment theory is that the residue of past interactions with the particular partner, as well as interactions in other past and present relationships, are stored in memory (e.g., Bowlby, 1973, 1982; Bretherton & Munholland, 2008; Collins, Guichard, Ford, & Feeney, 2004; Pietromonaco & Feldman Barrett, 2000; Zayas, Mischel, Shoda, & Aber, 2011). Mental representations consist of detailed memories of interactions with, and conscious and nonconscious affective evaluations of, attachment figures (e.g., Zayas & Shoda, 2005; Zayas & Shoda, in press), as well as strategies to regulate negative affect (e.g., turning to attachment figures to alleviate negative affect or turning away from attachment figures and coping through other means; e.g., Zayas, Shoda, Mischel, Takahashi, & Mischel, 2009) in stressful and threatening situations (e.g., Collins et al., 2004; Pietromonaco, Feldman Barrett, & Powers, 2006). Mental representations are impactful because they implicitly affect perceptions and expectations about likely events (e.g., if I seek help, then I will be supported; e.g., Baldwin et al., 1993; Zayas et al., 2009), which in turn affect physiology, emotion, and behavior, and may do so without any conscious awareness of the process (Günaydin, Zayas, Selcuk, & Hazan, 2012).

Dopaminergic/Reward System and Proximity Seeking
People move towards (approach) aspects of their environment that are rewarding and move away (avoid) those aspects that are not. The extent to which mental representations are associated with positive (or negative) evaluations in memory is assumed to guide approach and avoidance behaviors. A straightforward hypothesis is that various behaviors aimed at promoting proximity seeking (i.e., preferring one’s partner over others) and desire for closeness reflect underlying partner representations that are positively affectively laden and hugely rewarding. Indeed, research has found that partner representations automatically activate strong positive reactions (Zayas & Shoda, 2005), and that individual differences in the strength of the automatic evaluations predict relationship closeness, satisfaction, and relationship length (Zayas & Shoda, 2005) and breakup (Lee, Rogge, & Reis, 2010), even among newlyweds (McNulty et al., 2013).

Neuroimaging studies, using functional Magnetic Resonance Imaging (fMRI), have shown that activating the mental representations of a one’s partner, for example, by viewing a photograph of the partner, recruits the dopaminergic system (Aron et al., 2005; Bartels & Zeki, 2000). Dopamine-rich neural structures, such as the ventral tegmental area (VTA) and nucleus accumbens shell (NAS), are activated by stimuli with rewarding properties (e.g., food, sex, drugs, and neutral stimuli paired with reward) and are implicated in various manifestations of appetitive motivation and approach behaviors. Specifically, encountering a rewarding stimulus leads to a release of dopamine in the VTA, which projects to other structures in the limbic system such as the NAS. The activation of this pathway has been associated with subjective feelings of elation, excitement, desire and wanting, with promoting approach behaviors through activation of locomotion in the motor system, and with physiological changes, such as increases in
heart rate and blood pressure, via activation of the sympathetic nervous system (Balfour et al., 2004). Thus, findings that adult romantic partners activate this dopaminergic/reward system suggest that these individuals too are subjectively rewarding and that such neural activation promotes and maintains approach-related interpersonal behaviors, such as proximity seeking.

*Oxytocinergic/Opioid Arousal-Relief Systems and Safe Haven Functions.* Pair bonds are not simply defined by the experience of pleasure and joy they confer. One feature that distinguishes attachment figures from other personally close individuals is that they serve as a safe haven. Attachment figures provide a source of relief from distress. When one feels distressed—as a result of appraising the environment as threatening or the self as in need of help—she seeks proximity to her attachment figure. If the attachment figure is available and responsive, the resulting contact is expected to alleviate the distress and restore emotional and physiological balance.

What is critical in order for the distress-relieving properties to emerge is the shear repetition of interactions. Repeated positive interactions with attachment figures during times of stress reinforce the association in long-term memory between bids for support and stress reduction (e.g., Mikulincer & Shaver, 2003; Mikulincer & Shaver, 2007; Mikulincer, Shaver, & Pereg, 2003; Sroufe, & Waters, 1977). At a cognitive level, these repeated interactions are encoded in mental representations as *if...then...* contingencies, such as *if I turn to my partner, then I will feel safe* (e.g., Baldwin et al., 1993). At a physiological level, through processes of conditioning, the person providing the comfort eventually acquires properties that signal safety and relief (e.g., Beckes, Simpson, & Erickson, 2010). Thus, eventually, simply the mental representation of the attachment
figure, even in the absence of the attachment figure’s actual presence, becomes capable of activating psychological and physiological states of safety and calmness originally induced by actual interactions with them (e.g., Depue & Morrone-Strupinsky, 2005; Uvnäs-Moberg, 1998).

Indeed, numerous studies provide support for the proposition that partners enhance affect regulation (see Sbarra & Hazan, 2008; Selcuk, Zayas, & Hazan, 2010, for reviews). For instance, intimate and supportive interactions with a romantic partner, compared to nonsupportive interactions with a partner or being alone, lead to greater calmness while anticipating a stressor (e.g., Simpson, Rholes, & Nelligan, 1992), smaller elevations in self-reported anxiety and physiological reactivity (i.e., systolic blood pressure, diastolic blood pressure, heart rate, and cortisol level; e.g., Collins & Ford, 2010; Ditzen et al., 2007; Grewen et al., 2003) and attenuation of neural threat responses while experiencing a stressor (e.g., Coan et al., 2006), and faster emotional recovery following a stressor (e.g., Collins & Ford, 2010). Moreover, some of the distress-relief benefits are realized simply by activating the mental representation of the partner, in the absence of his or her actual presence. For example, simply viewing a photograph of one’s partner diminishes the experience of a mildly painful stimulus (Eisenberger et al., 2011; Master et al., 2009) and lessens the deleterious affective and cognitive consequences of relieving a distressing autobiographical memory (Selcuk, Zayas, Gunaydin, Hazan, & Kross, 2012).

A growing body of research has focused on identifying the neural and endocrinological mechanisms that confer these distress-alleviating effects. This work, both from the human and animal literatures, converges on the idea that interactions with
attachment figures, whether actual or symbolic, increase activity of two neurotransmitter systems: Oxytocin (OT), which promotes feelings of trust, love, security, and affiliation, and endogenous opioids, such as beta-endorphins, which promote relaxation, well being, and most importantly, decrease the experience of physical and emotional pain (Depue & Morrone-Strupinsky, 2005; Sbarra & Hazan, 2008; Young & Wang, 2004). The release of these neurotransmitters, in turn, serves to down-regulate threat-related reactivity of the hypothalamic-pituitary-adrenocortical axis (HPA) and the autonomic nervous system (ANS) (Diamond, 2001; McCubbin, 1993; Uvnas-Moberg, 1998).

The threat response of the HPA and ANS has been well documented. In response to an external or internal threat, the hippocampus, involved in memory, and the bed nucleus of the stria terminalis (BNST) of the amygdala, an important brain region in the anxiety pathway, become activated and trigger a cascade of physiological responses to signal potential danger. In particular, the BNST, which provides threat feedback to the hippocampus, produces corticotropin-releasing hormone (CRH), a precursor to cortisol—the stress hormone (Aguilera & Liu, 2012). This activates an autonomic nervous response by releasing cortisol (a glucocorticoid) into the bloodstream. This pathway occurs in a feedback loop that causes enduring hyperexcitability until the potential danger passes.

Oxytocin and mu-opiates serve as an anxiolytic and essentially downregulate this HPA activation. Both neurotransmitters are released in response to various affiliative and social cues. For example, OT is released in response to hugging, physical touch, sexual interactions, and orgasm (Insel, 1992) and µ-opiates are released in response to caressing touch, ventro-ventral contact, and sexual activity, especially genital stimulation (Insel, 1992; Nelson & Panksepp, 1998; Silk et al., 2003). To the extent that past experiences
with partners involved these interactions, these physiological states are encoded into the mental representation of the partner, and eventually simply bringing the representation of the partner to mind, even in the absence of their physical presence, is sufficient to trigger their release (Carter, 1992).

Once released, OT and opiates serve to downregulate the HPA threat response. OT circulates centrally through the paraventricular nucleus (PVN) of the hypothalamus and has a negative influence on a number of areas involved in the detection and processing of threat, such as the anterior cingulate cortex (ACC), which is implicated in stress and emotional processing, the BNST, amygdala, and hippocampus. The negative influence on the BNST subsequently reduces the amount of CRH produced, and thus cortisol, effectively reducing the duration of the stress response (Liberzon & Young, 1997; Oliet et al., 2007; Aguiler & Liu, 2012).

*The Sexual Mating System*

The sexual mating and attachment systems are distinct and independent and have evolved to serve different functions (Diamond, 2004). Nonetheless, we propose that sexual intercourse activates several physiological and neural systems that overlap considerably with the attachment behavioral system. One correlate of our argument is that if sex is repeated with the same partner over time, neural and physiological states of sexual activity will become conditioned to the partner, and to the extent that these processes overlap with those underlying the attachment system, sex is expected to promote feelings of attachment security and facilitate the formation of the pair bond.

In the section that follows, we briefly describe the neural and hormonal systems associated with two constituent parts of sexual activity: the incentive-motivation reward
system implicated in the appetitive phase (also known as the approach phase) that regulates sexual motivation, sexual desire, sexual arousal, and courtship behavior (Woolley, Sakata, & Gupta, 2001) and the consummatory system implicated in the consummatory phase, which is involved in feelings of satiation and sedation following attainment of the goal (Hinde, 1970).

To illustrate the basic activation of the sexual mating system (and later how it might promote adult attachment), in the sections that follow, we will refer to a hypothetical scenario in which two individuals, Sam and Alex, meet for the first time and experience sexual attraction. A number of cues, such as facial shape and appearance, scent, body posture, and so on, will affect whether Sam will find Alex attractive.

*The Appetitive Phase*

*The role of the dopaminergic/reward system.* The appetitive phase in initial attraction and romantic interest is governed by the same incentive-motivation reward system active in many other fundamental behaviors, such as eating, sleeping, and drinking (Depue & Collins, 1999; Gray, 1973; Panksepp, 1986). In reference to sexual motivation, this system is active in sexual motivation and the anticipation of sexual interaction. Moreover, both the incentive-motivation reward system and the consummatory system (discussed next) play prominent roles during actual sexual intercourse. The overlap between the two systems during intercourse that once distal cues (the possibility of sex) give way to proximal cues, as well as the incentive and possible anticipatory release of dopaminergic reward that precedes various sexual behaviors (e.g., orgasm) during the sexual encounter.

Similar to other approach behaviors, the incentive-reward motivation system is
involved in the appetitive phase of sexual activity involving sexual desire and motivation. Sexual desire characterizes the myriad of behaviors that could be referred to as “courtship” and lead up to the goal of actually having sex. Thus, approach behaviors range in their proximity to the goal, from seemingly distal behaviors, such as a phone call, glance of the eyes, touch of the hand, to more proximal actions such as kissing, undressing the partner, and foreplay. All of these phases are considered appetitive in that they still involve approaching actual sexual interaction, but not having them.

In all varied aspects of these approach related behaviors, the incentive-motivation system is at work and reflects the dopaminergic reaction in the mesolimbic reward centers of the brain (e.g., VTA, NAS) triggered in response to a rewarding stimuli. When Sam meets Alex for the first time, a number of cues, such as facial shape and appearance, scent, body posture, and so on, will affect whether Sam will find Alex attractive. Research shows that initial evaluations of attraction based on a photograph not only activate dopaminergic-reward areas, but that initial evaluations of interest are strong predictors of actual behavioral intentions to date the person later (in a speed dating paradigm; Cooper et al., 2012). So, for Sam cues associated with Alex, someone she inherently finds physically attractive, serve to activate the appetitive neural and behavioral system. Subjectively, Sam simply seeing Alex is likely to elicit an ecstatic high from DA release, which is a subjective high associated with stimuli that are the most rewarding, actually occurs before Sam reaches Alex in anticipation of the reward she will receive by interacting, possibly successfully, with an attractive potential mate. Behaviorally, this anticipatory dopaminergic reward occurs in order to propel an individual towards a rewarding stimulus, not to receive the reward itself (Depue &
Collins, 1999). Sam will likely desire to engage in a number of approach-oriented behaviors, such as physically get closer, talk with, and maintain eye contact with Alex (Breiter et al, 2001; Aharon et al., 2001).

Magnitude of affiliative reward. Although the reward system is involved in the processing of a wide range of rewarding stimuli, one difference in processing underlying affiliative interactions with a potential partner as compared to the processing of other rewarding in stimuli (e.g., food) is in the magnitude of the neural activation and subsequent response (Meston & Frohlich, 2000). The incentive-motivation system responds proportionally to the magnitude of the perceived reward (Depue & Morrone-Strupinsk, 2005). For example, the amount of DA released by the VTA is directly dependent on how rewarding the experience is expected to be, as the appetitive reward is of an anticipatory nature. If the stimulus is more or less rewarding when experienced, then the incentive-motivation system adjusts, through feedback from the consummatory opiate reward system, to this difference and adjusts the expected reward accordingly (Depue & Collins, 1999). In this regard, sex (and the possibility of it), is one of the most powerful rewarding stimuli (Meston & Buss, 2007; Pfaff, 1999), triggering a large amount of dopaminergic action in the NAS (Pfaus et al., 1995). Returning to Sam and Alex, the appetitive phase is characterized by a highly excited state as they approach one another and engage in a variety of sexual behaviors. Moreover, the highest dopaminergic release during sexual activity happens approximately two minutes before the point of orgasm when a large amount of dopamine is released in expectation of the impending reward stimulus (Young & Wang, 2004). Therefore, there is a dopaminergic reward delivered in anticipation of achieving the goal of sexual activity, as well as a separate
dopaminergic reward delivered in anticipation of achieving the separate goal of orgasm.

Potentiation of reward processing via OT activation. Relatedly, a second way in which the processing of affiliative stimuli differs from the processing of rewarding stimuli in other domains is due to the interactions between the dopamine (DA) system functioning and oxytocin, vasopressin, and µ-opiates (Depue and Morrone-Strupinsk, 2005). Dopamine in the NAS may increase sexual arousal, and penile erections, through the release of increasing central oxytocinergic activity when presented within the behavioral context of responding to a sociosexual stimulus (Argiolas, 1999). Similarly, oxytocin increases the dopamine release in VTA to the NAS, which leads to increased dopaminergic activity and increased sexual motivation (Melis et al., 2007). Studies in mice, rats, and prairie voles have found that oxytocin’s ability to innervate dopamine neurons in the VTA sensitizes the reward system to dopamine (Kovacs, Sarnyai & Szabo, 1998; Shahrokh et al., 2010). This makes the incentive reward to sexual stimuli greater in magnitude, since the magnitude of dopamine being released in the brain increases.

One important implication of the interactions between OT and DA is with the formation and development of mental representations. It has been hypothesized that interactions between dopamine and oxytocin during the appetitive phase enhance the encoding of social contextual ensemble (e.g., partner scent, touch, facial structure) and reward associations that are defining features of mental representations (Argiolas, 1999). Subsequently, this may be one pathway by which sex facilitates the process of transforming representations of a stranger to the representation of a partner, and thus creating a lasting pair bond (Lim & Young, 2006).

The Consummatory Phase
If dopamine is released prior to the reward (during goal pursuit), this begs the question: What happens once Sam and Alex have actually reached the their goal of sexual activity? In this example case, what happens neurologically to Sam and Alex beginning during their sexual encounter and continuing once they have finished copulating and their orgasms have taken place (hopefully). The answer is that by being in close proximity to their goal, in this case a sexual interaction with a sexually desirable mate, the appetitive reward phase moves on to the consummatory reward phase (Herbert, 1993). Some examples of what constitute a proximal cue, as opposed to a distal cue, that signals the consummatory phase would be sexual touch, gentle stroking, and running your hands through your partner’s hair, as well as genital stimulation and orgasm. Essentially, where appetitive reward was delivered before and during sex, consummatory reward is delivered during and after sex.

While appetitive reward is characterized by desire and arousal, consummatory reward is characterized by feelings of liking, pleasure, and gratification (Smillie, 2013). Similarly, while appetitive reward triggers approach-oriented action, consummatory reward triggers a cessation of approach behavior, namely, sedation and rest (Hilliard et al., 1998). Thus, consummatory reward reinforces the behaviors initiated and sustained by appetitive reward (Porges, 1998; Porges, 2001).

In the case of Sam and Alex, the consummatory reward system becomes active once they have become proximal to their goal, which is in this case to engage in sexual touch and activity with one another. During the sexual encounter, the consummatory reward overlaps with the incentive motivation system. This is because the incentive-motivation system is still driving Sam and Alex towards orgasm, which is a separate,
though often associated, reward goal (Berridge, 1999). At the end of this sexual interaction, Sam and Alex should feel gratified, calm, satiated, and lethargic.

Oxtocingergic and opioid system and consummatory phase. Consummatory reward is characterized by endogenous endorphin and opioid action in the brain, a system whose involvement in pair bond maintenance in non-human primates has been confirmed and may yet be even more important in humans (Machin & Dunbar, 2011). In the case of sociosexual interactions, beta-endorphins are released and interact preferentially with mu-opioid receptors (MOR) (Keverne et al., 1989). Beta-endorphins are actually the most potent endogenous opioid peptide, with 80 times the analgesic potency of morphine, which also binds to the mu-opioid receptors. Regardless of the potency of beta-endorphins, the number of mu-opioid receptors directly affects the subjective experience of consummatory reward, and the prevalence of these receptors in the brain is affected by age and early life experiences (Machin & Dunbar, 2011). Activation of these mu-opioid receptors in the central nervous system (CNS) causes a decrease in heart rate and blood pressure and feelings of euphoria and sedation, which is mediated by increases in inhibitory parasympathetic activity (Irnaten, 2003). This opiate receptor activity also increases pain thresholds, and may be responsible for the elevated pain thresholds that are seen in concert with romantic relationships and during orgasm (Younger et al., 2010; Whipple & Komisaruk, 1985). The magnitude of opiate receptor activation, which is the incentive value of the stimuli, is encoded along with the sensory cues of the immediate surrounds, associated feelings, and distinct characteristics of the sexual stimuli (usually the partner) in frontal cortex and hippocampus. This information is then used to determine the expected magnitude of the reward the next time this contextual ensemble
takes place and the subsequent appropriate anticipatory reward to incentivize individuals towards the sexual stimulus (Depue & Morrone-Strupinsk, 2005).

With regard to the consummatory phase, when the potential reward is proximal to the person, β-endorphin-related opiate peptides (mostly µ-opiates but also sometimes δ-opiates) are released in response to introceptive (internal cues, such as emotions, feelings, or arousal) and proximal exteroceptive (external cues, such as physical manifestations of a close reward goal or objective) stimuli (Hillard et al., 1998; Depue and Morrone-Strupinsk, 2005).

β-endorphin-related opiate peptides are also active in the VTA and NAS pathway, similar to DA. People who were given an opiate antagonist reported that their orgasms were less pleasurable than participants on a placebo. Essentially, the role of opiates in sexual experiences is to enhance the subjective experience of pleasure, satiation, and calm arousal relief. After sexual activity, µ-opiates are activated, especially in an important area for sexual reward processing, the mPOA (medial preoptic area), within about 30 minutes post-coitus, and are internalized continuously for approximately 6 hours (Coolen et al., 2004). However, in high doses, µ-opiates have an inhibitory effect on the appetitive process, and lead to reduced sexual desire, making it more difficult (along with prolactin) to have consecutive, repeated sexual encounters. This is because it is very unusual for both the appetitive and consummatory reward processes to be active at the same time, just by the virtue of their respective functions, with the exception of the cross-over during sexual activity. Therefore, the interneurons in the dopaminergic pathway between the VTA and NAS are regulated by µ-opiod receptor activation that can inhibit DA receptors from firing (Balfour et al., 2004).
**Oxytocin during the consummatory phase.** Murphy and colleagues (1990) also suggest that µ-opiates are related to its interaction with the release of oxytocin. An important interaction that can be found between oxytocin and the endogenous opiate-endorphin system is that oxytocin inhibits the development of a tolerance to opiates (Machin & Dunbar, 2011; Kova´cs, Sarnyai & Szabo´, 1998). This has the very important effect of preventing the magnitude of the consummatory reward from decreasing over time. While the incentive motivation dopaminergic reward is sensitized by oxytocin and then habituates over time, the consummatory opioid reward stays constant due to the effects of oxytocin.

Cantor and colleagues (1999) found that oxytocin is necessary for ejaculation to take place. This is not surprising given that orgasm, often associated with ejaculation in both men and women, causes an increase in oxytocin around that time of orgasm until about five minutes afterwards (Carmichael et al., 1987). Though the exact role, magnitude, and longevity of oxytocin during and after orgasm has been a matter of debate in the literature, especially concerning male participants (Kruger et al., 2003a; Murphy et al., 1987), there is general agreement that oxytocin levels do increase due to orgasm in men and women (Blaicher et al, 1999; Caldwell, 2002). However, it is also true that oxytocin is released throughout most sexual activity due to the physical intimacy of sexual intercourse (Meston & Frohlich, 2000).

**The Role of Sex in Adult Attachment Formation**

We propose that the sexual mating system, which governs attraction, flirting, desire, and sexual behavior, plays a critical role in adult attachment formation. Specifically, we argue that through repeated sexual interactions with the same partner, the
physiological and endocrinological states that sex engenders become encoded into the mental representation of the partner. By doing so, it promotes the development of mental representations from one of an attractive, but unknown, stranger to one that is rewarding, complex, and ultimately underlies a full-fledged attachment bond.

There are multiple social, cognitive, behavioral, and neural pathways in which sex may affect attachment processes. Here, we focus on the overlap between attachment and sexual mating system in the dopaminergic and oxytocin/opioid mechanisms, and how via shared neural mechanisms, sexual activity may promote the formation of an adult attachment bond. We focus specifically on two aspects of the sexual mating system that are likely to have profound effects on the development of the attachment bond: (i) the reward-related, dopaminergic and opiate activity associated with sexual activity and (ii) the negative reinforcement properties associated with sexual interactions.

The reward-related, dopaminergic-activity associated with sex

Sex is a powerful reward. Not surprisingly, individuals who are perceived as sexually attractive (and thus could be a sexual partner in the future) or have been sexual partners in the past are associated with rewards, trigger dopaminergic-reward processing (as described in the previous section). The sheer magnitude of the reward response triggered by sexual partners (future or actual) has several implications for the development of an attachment bond.

First, such reward processing promotes promoting proximity-seeking and maintenance. Proximity is not only an important factor contributing to initial attraction (Berscheid & Walster, 1969), but sustained proximity is necessary for the formation of pair bonds (Hazan & Zeifman, 1994). Given that aspects of the environment (e.g., certain
groups or particular people, objects, and places) that are highly positive and associated with reward, lead to more approach behavior, it is self-evident that the promise of sexual reward is a motivator for initiating and promoting proximity seeking behaviors early on in the relationship. Indeed, physical attractiveness has long been identified as a key factor in initial attraction and relationship initiation, motivating individuals to approach certain persons (those who are attractive) and desire to spend time with them.

Second, the combination of dopaminergic, oxytocinergic, and opiate activity during sex has implications for memory and encoding, and specifically for building a robust, context-independent, chronically accessible mental representation of the partner, which is a defining cognitive feature of attachment bonds (Zayas, Gunaydin, & Shoda, in press). In this manner, partner representations can be easily activated in a number of situations and used to guide behaviors and color experience.

Specifically, dopamine, oxytocin, glutamate, and µ-opiate action, especially in the brain’s reward pathway and medial orbital 13 region, activated during sex play critical roles in encoding information about the partner (e.g., partner’s smell, touch, sound, and appearance) into an ensemble of cues (Luu & Malenka, 2008; Depue & Morrone-Strupinsk, 2005). The strong activation of the dopaminergic, oxytocinergic, and µ-opiate systems by sex and sexual partners suggests a neural pathway by which mental representations may become richer and more elaborated more quickly than if the sexual mating system were not activated. It also provides a neural mechanism for how the representation of the partner may become chronically accessible (always on one’s mind or brought to mind with little effort) and contextually-independent. Returning to our hypothetical scenario, the high dopaminergic, oxytocinergic, and opiate activity during
sex likely means that Sam and Alex will more readily encode each other’s cues into their respective mental representations.

Another way in which attachment representations may develop more quickly is through behavioral mechanisms differentially triggered by neural activity. That is, positive, rewarding stimuli are more salient, and more likely to grab attention, compared to less positive or neutral stimuli. Thus, behaviorally, individuals are more likely to form richer representations of any information involving their potential sexual partner simply because he or she is the most rewarding and salient aspect of the environment. Indeed, in parent-child and sexual relationships, individual characteristics (e.g. scent, facial features), are very closely inspected investigated (Cruz & Del Cerro, 1998).

Negative reinforcement

There are certainly important differences between the cognitive and behavioral components of distress-relief processes and those associated with arousal-relieve during sexual activity. Still, there are a number of similarities.

First, negative reinforcement is common in both. In distress-relief, a person feels anxiety and another person who serves to comfort them will eventually become associated via conditioning with relaxation. Thus, later, even in the absence of actual physical comfort, the mere thought of the partner gives rise to feeling and physiological states of security. Likewise, during sexual encounters there is a period of sustained positive arousal during the appetitive phase, occurring before and during sexual activity, which is then followed by relief and satiation during the consummatory phase, occurring during and after sexual activity. The arousal associated with the appetitive phase is excitatory and anticipatory, activating the autonomic nervous system and increasing heart
rate, vascongestion, and even activating the BNST of the extended amygdala, which releases extracellular DA (Phillips-Farfan & Fernandez-Guasti, 2007; Eiler et al., 2007. However, after sex (and orgasm) there is a large release of oxytocin and μ-opiates that signals sexual satiety. In this state, the BNST is not activated and a peaceful, almost lethargic, state of calm sets in (Phillips-Farfan & Fernandez-Guasti, 2007). This deactivation of the autonomic nervous system is also evident in poistcoital bradycardia, when the heart drops below 60 beats per minute (Cater, 1992). Thus, sexual encounters mimic distress-relieve in this respect.

Moreover, the neural and hormonal systems underlying the distress-relief and those underlying the arousal-relief characteristic of sexual encounters show considerable overlap. Most important, both distress-relief and sex involve the release of oxytocin. In distress-relief, OT receptors in the hippocampus are regulated by the release of glucocorticoids. Specifically, the feedback of glucocorticoids, such as cortisol, released by stress increases OT receptor binding (Liberzon & Young, 1997). Increased glucocorticoid receptors in the hippocampus are associated with increased OT receptor binding in that area, which, through the action of GABA, has an excitatory effect on the pmBNST, which in turn reduces the release of PVN CRH, and through that action, cortisol. Therefore, it is through the release of stress hormones that OT receptors are up-regulated, which in turn enhances the action of oxytocin released through physical touch, such as ventro-ventral eye contact, or the accessing of a mental representation. In sexual interactions, a powerful release of oxytocin is associated with breast and genital stimulation, uterine contractions, contractions of the reproductive tract, sexual arousal, the act of coitus, and, most potently, orgasm (Carter, 1992). The other acts that release
comparable amounts of oxytocin are lactation, parturition, and regulation of maternal behavior (Carter, 1992).

With the large role that oxytocin plays in sexual functioning and release, along with its interaction with dopamine in the **NAS**, it is reasonable to hypothesize that the anxiolytic and intimacy-promoting effect of oxytocin is amplified during positive sexual encounters - especially one’s resulting in orgasm for one or both of the partners. This continued distress relief and increase in trust and intimacy from repeated sexual encounters could then act to create the adult attachment bond, much like distress relief did in infancy.

*Ingredients necessary for an attachment relationship: Dopamine, Opioids, and Oxytocin.*

Thus far, we have discussed the role of dopamine, oxytocin, and opioids as functioning relatively independently. However, it is possible that a true bond cannot be formed without a combination of these neurochemicals. Studies done by Young and Wang (2004) with prairie voles have found that blocking *either* the dopamine *or* the oxytocin receptors in prairie voles prevented their ability to form a pair. Even when a D2 receptor agonist was used to induce partner preferences in the prairie voles, no preferences were formed when there was also a blockade of oxytocin receptors.

Various findings suggest that the formation of pair bonds involves the presence of both dopamine and oxytocin (and vasopressin). Specifically, the release of oxytocin in the dopaminergic pathway, specifically the NAS (oxytocin) and the ventral palladium (vasopressin), appears to enhance reward processing and memory formation needed for acquiring mate preferences (Argiolas & Gessa, 1991; Sarnyai & Kovacs, 1994).
Consistent with this proposition, in animals (sheep, voles, and rats), oxytocin antagonists and PVN lesions prevent the formation of partner preferences, as well as the onset of maternal behaviors (Oskrowski, 1988). Interestingly, they do not stop sexual or maternal behaviors after these behaviors have already been established.

This work points suggests that oxytocin (and vasopressin) affect the formation of mate preferences and the development of mental representations by acting as catalysts in the appetitive reward system. Specifically, oxytocin increases sensitivity to the huge release of dopamine that anticipates and accompanies sexual behavior, making sex more rewarding than food or cocaine (Kovacs, Sarnyai & Szabo, 1998; Shahrokh et al., 2010). This interaction between oxytocin and dopamine also characterizes the infatuation phase of relationship development.

However, it is important to note that the relative potency of neurohormones varies as the relationship progresses. Over time, as a result of habituation, the dopaminergic response associated with sex is expected to decrease. Critically, however, even though dopaminergic reward becomes less and less intense, the opiate release associated with consummatory reward during and after sex does not lessen, as oxytocin, importantly, inhibits the development of tolerance to these opiates (Kovacs, Sarnyai & Szabo, 1998). This opiate-consummatory release, coupled with the tolerance inhibiting effects of oxytocin, is what is expected to maintain feelings of attachment even after the dopaminergic high elicited by the sexual system declines.

**Unanswered questions and future directions**

*When does having sex hinder the formation of an attachment bond? Integration with the relationship literature findings*
We have proposed that sexual interactions with the same partner over time are likely to promote the formation of an attachment bond. But, are there instances in which sex might impede the formation of pair bonds. Just like there is an absence of theorizing on the broader issue of the role of sex in adult attachment formation, there is no work directly looking at the question of whether sex might hinder attachment formation. However, the relationship literature looking at the role of sex on relationship outcomes (e.g., satisfaction, breakup) may shed some light.

The extant, and relatively recent, findings in the relationship literature suggest that the timing of sex during relationship formation is a critical factor in determining whether sex predicts positive or negative relationship outcomes. In a national sample of 2,035 married individuals, Busby et al. (2010) found that couples who waited until marriage to have sex compared to those who started having sex early in their relationship reported higher marital satisfaction, better communication patterns, fewer thoughts of divorce, and better sexual quality. Couples that became sexually involved later when dating, but prior to marriage, fell somewhere in between, showing better relationship outcomes than those who had sex early on in the relationship, but worse outcomes than those who waited until marriage. Moreover, these results held even when statistically controlling for a variety of other variables (e.g., number of sexual partners, relationship length, religiosity, education). Another study by Busby and colleagues (Willoughby, Carrol, & Busby, 2014) reported similar findings. However, before drawing any conclusions, it is important to keep in mind that relationship stability, which is typically the focus of relationship researchers, is not the same as the quality of the attachment bond (Selcuk, Zayas, & Hazan, 2010). That is, behaviors that characterize the attachment bond,
such as partner’s providing each other with a subjective sense of felt security, regulating each other’s affective and physiological states, and facilitating each other’s functioning outside the relationship, occur independent of the level of satisfaction experienced in the marriage. Indeed, such attachment behaviors may even occur when the marital relationship itself is not very satisfying. Thus, the specific question of whether timing of sex plays a role in moderating the hypothesized effect of sex on adult attachment formation requires empirical investigation. Future work, ideally using a longitudinal framework, should be used to more precisely examine how the timing of sexual intercourse affects subsequent components of the attachment bond (e.g., alleviation of distress).

*How do attachment bonds differ as a function of whether the relationship is sexual or platonic?*

This model effectively describes the formation of any affiliative bond, however, the key difference in the contribution of sex is twofold: the magnitude of the dopaminergic and opiate rewards and the administration of oxytocin. While platonic affiliative bonds and social contextual ensembles can be created without the inclusion of sex by this approach-consume reward system, it is the presence of sex and sexual motivation that makes a traditional, sexual pair bond so special. It would take a great magnitude of reinforcement, both positive in the form of reward and negative in form of arousal and distress alleviation, for a peer to replace one’s caregiver in the attachment hierarchy. Therefore, it is possible, with the inclusion of soft touch, mutual eye gaze, and ventro-ventral contact, in order to release µ-opiates and oxytocin, for platonic bonds to form. However, it is far more likely that, given the unconditioned reward sexual pleasure
presents and the vast differences in the magnitude of reward coupled with oxytocinergic activity elicited by sexual encounters that our adult primary attachment relationships will be with a sexual partner.

Does the proposed model work for people who engage in casual sex or who are serial monogamists?

We speculate that both people who engage in casual sex or who are serial monogamists might find the incentive motivation dopaminergic reward to be more valuable than the consummatory opiate reward. A preference for dopamine-related activities over opiate-related ones may reflect individual differences. For example, people who prefer casual sex or the beginning of relationships may be more sensitive to dopaminergic (vs. opiate) rewards, which would promote a preference for high-dopaminergic activities, such as sex, compared to high-opiate activities associated with longer relationships. Additionally, they may have less mu-opioid receptors due to early life experiences. In fact, people who prefer casual or brief encounters may be the neurochemical opposite of people who identify as asexual, who experience consummatory reward, but have no sexual incentive motivation.

Additionally, those who prefer casual sex or who are serial monogamists may have a preference for dopamine-related activities over opiate-related because of the release of oxytocin. Although oxytocin is released by touch, orgasm, sexual intercourse, nipple stimulation, and similar intimate behaviors, sexual encounters consisting of fewer of these actions will trigger less oxytocin release. For example, perhaps people who prefer casual sex also tend to have less nipple stimulation, less ventro-ventral contact, less consistent orgasms, less soft touch, etc. If this is the case, less oxytocin will be
released, and while the dopaminergic reward will not be as sensitized, there will also be less inhibiting of opiate habituation. If that is the case, then once they have habituated to the dopaminergic reward, they will also have habituated to the opiate reward, thus receiving what subjectively feels like and what neuroendocrinologically is less reward. Instead of moving from an exciting, sexually motivating reward to a peaceful gratifying reward, these people may be feeling very little reward. Examining the role of sex and attachment formation for people who prefer almost exclusively causal sex or who are only interested in the infatuation stage of a relationship would be a promising way of examining the function of sex in attachment formation.

*Does the proposed model work for asexuals?*

Asexual individuals do not experience sexual attraction to others. On a sexual orientation (romantic/erotic response) spectrum with “attracted to women” on one end and “attracted to men” on the other, asexuality rests at the midpoint along with bisexuality and pansexuality. Approximately 1% of the population self-identifies as asexual. Among asexuals there is a further distinction between a romantic and an aromantic orientation. Romantic asexuals enjoy the physical intimacy of nonsexual touch whereas aromantic asexuals typically find even nonsexual physical intimacy aversive. Given our theorizing, we predict that adult attachment formation among asexuals would be driven primarily or exclusively by the oxytocinergic and opioid systems, and *not* the dopaminergic (wanting, desiring, sexual motivation) system.

*Orgasm and gender differences*

It is well-documented that when men and women have sex, men are far more likely than women to achieve sexual orgasm, especially in the form of sexual intercourse.
Does this mean that women’s attachments to their partners form more slowly, less strongly, less often? There is also evidence that female same-sex couples are less sexually active but cuddle more than male same-sex couples. Does this mean that lesbians are less or differently attached to their partners than gay males? Based on these findings and our theorizing, we hypothesize that the primary difference in the relationship between sex and attachment in women versus men is the balance of dopaminergic to oxytocinergic rewards. In other words, men on average tend to enjoy sexual novelty more than do women and women on average tend to enjoy sexual intimacy more than do men. We can see this sex difference in interactions with sexual stimuli in a study by Festjens, Bruyneel, and Dewitte (2013) in which heterosexual men and women were presented with underwear or a t-shirt of the opposite sex and were either allowed to touch or only look at them. Men exhibited more reward-seeking after both visual and tactile cues of women’s underwear. However, women only exhibited reward-seeking after being allowed to touch the men’s underwear, as visual cues alone were unable to elicit an appetitive response. This sex difference is perhaps due to a differentiation in the dopaminergic threshold that is required to experience sexual motivation, and having an additional sensory experience was necessary for the women in the study to reach this threshold. Alternatively, given the behavioral conditioning response associated with the reward system, perhaps the majority of women in this study had experientially learned not to associate male undergarments with the magnitude of anticipatory reward that men had. This experiential learning could stem from the saturation of sexualization of women and women’s underwear in mainstream culture or even from an antiquated, yet still pervasive, view of women not acting as sexual aggressors.
Another possibility for the sex differences we find between men and women’s sexual inclinations towards novelty vs. intimacy, respectively, may be due to the gender difference in internal hormonal milieu. The Steroid/Peptide Theory of Social Bonds (van Anders, Goldey, & Kuo, 2011) calls attention to the seemingly opposing processes of oxytocin and testosterone in social bonding: where oxytocin promotes trust, testosterone inhibits it, where oxytocin promotes empathy, testosterone inhibits it, where oxytocin inhibits stress, testosterone promotes it (Bos et al., 2012). Van Anders and colleagues (2011) even go so far as to say that testosterone and oxytocin seem to act as hormonal antagonists to one another. From this antagonistic relationship between testosterone and oxytocin presented in the Steroid/Peptide Theory, it would be reasonable to extrapolate that by men having more testosterone than women, men would need a larger amount of oxytocin in order for the neurotransmitter to have the same effect in promoting pair bonding as it does in women. This may be one reason why, separate from social constructionist viewpoints, it is more common for men to orgasm during a sexual experience than women, as it may allow for a more equitable action of oxytocin in the two partners. Future research might investigate sex differences in hormone and neurotransmitter interactions and their effects on attachment formation.

*Individual differences in sex & attachment*

There will be, of course, individual differences in how sex affects attachment formation and maintenance. These include, to name only a few, individual differences in thresholds for experiencing incentive dopaminergic reward or opiate consummatory reward, individual differences in the number of oxytocin and glucocorticoid receptors in the hippocampus, or the attachment styles that shape individuals expectations and
behaviors within relationships. Most relevant is empirical work by Gurit Birnbaum and her colleagues (2012; 2010; 2007; 2006) investigating how individual differences in adult attachment relate to the experience of sex. For example, securely attached people prefer their sexual interactions to be committed romantic relationships, and find these sexual experiences mutually satisfying and intimate with their partner. Avoidantly attached individuals tend to engage in less-frequent sexual activities with relationship partners (Birnbaum, 2010), dislike and are uncomfortable with the physical and emotional intimacy that accompanies sex in a relationships, and prefer to detach the physical intimacy of sex from the its psychological intimacy implications (Mikulincer & Shaver, 2007). Not surprisingly, then, avoidant people feel disconnected from their partners during sexual experiences and display less physical affection (Birnbaum & Reis, 2006). Finally, anxiously attached individuals look to sex, in particular, to fulfill other deficits in attachment-related needs, leading to a promotion of attachment-related reasons for engaging in sexual activity, and the paramount importance of the affection aspects of sex over even the sex itself (Birnbaum, 2010).

Based on this literature, we speculate that it would be difficult for people with an avoidant attachment style to receive the same magnitude of oxytocin release, associated with physical touch, as well as psychological trust and intimacy, in their relationships, compared to securely attached. If so, this would subsequently affect the formation and maintenance of attachment bonds on a neurological and cognitive level for people who are avoidantly attached.

With respect to anxiously attached, we predict that the relationship-based anxieties that anxiously attached individuals feel may lead them to deny their own sexual
desires and needs in order to please their partners, which would prevent them from getting the amount, and type, of neural/endocrinological rewards that they desire (and possibly need to feel secure in their attachment), as well as increasing their anxiety in general (Birnbaum, 2006).

**Conclusion**

Although it is the norm that romantic partners function as attachment figures and sex partners, and pair bonds in theory are characterized by an integration of the attachment and sexual mating systems, sex has largely been ignored by researchers focusing on adult romantic attachment. (Birnbaum’s et al.’s (Birnbaum & Reis, 2006; Birnbaum, 2010) work, though its focus is individual differences and not the role of sex in attachment formation, is a notable exception.)

Based on the evidence reviewed above, it is clear that the neural and physiological systems operating during sexual exchanges overlap significantly with those underlying attachment bonds. Notably, oxytocin is released most strongly in the context of the two types of interpersonal relationships that typically function as primary attachments—i.e., infant-caregiver bonds in early life (including parturition and lactation) and romantic/sexual bonds in adulthood.

The neural systems that motivate us to engage in sexual interactions and then reward us so intensely for doing so appear to play a central role in adult attachment formation. Specifically, repeated sexual contact with the same individual over time conditions these systems to a rich mental representation of him or her that includes facial and bodily features, voice, smell, touch, etc. In the normal course of romantic relationship
development the dopaminergic reward declines in intensity but, thanks to oxytocin, the opiate reward does not. Indeed, the point of “clear-cut” attachment in adulthood—i.e., the marker of a qualitative change from infatuation to full-blown attachment—may be when an opiate-based sense of calm and satiety overtake dopamine-driven feelings of desire. Further, the action of oxytocin in preventing habituation to the rewarding effects of opiates is what helps maintain pair bonds over the long term.

We hope the ideas presented in this chapter will inspire adult attachment researchers to tackle the many fascinating and empirically testable questions that the proposed model suggests, and thereby help move the field of adult attachment theory forward.
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