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Defining the Brain Systems of Lust, Romantic Attraction, and Attachment

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Mammals and birds have evolved three primary, discrete, interrelated emotion–motivation systems in the brain for mating, reproduction, and parenting: lust, attraction, and male–female attachment. Each emotion–motivation system is associated with a specific constellation of neural correlates and a distinct behavioral repertoire. Lust evolved to initiate the mating process with any appropriate partner; attraction evolved to enable individuals to choose among and prefer specific mating partners, thereby conserving their mating time and energy; male–female attachment evolved to enable individuals to cooperate with a reproductive mate until species-specific parental duties have been completed. The evolution of these three emotion–motivation systems contribute to contemporary patterns of marriage, adultery, divorce, remarriage, stalking, homicide and other crimes of passion, and clinical depression due to romantic rejection. This paper defines these three emotion–motivation systems. Then it discusses an ongoing project using functional magnetic resonance imaging of the brain to investigate the neural circuits associated with one of these emotion–motivation systems, romantic attraction.

KEY WORDS: romantic attraction; sex drive; FMRI; neural circuits.

INTRODUCTION

Neuroscientists currently believe that the basic emotions arise from distinct circuits (or systems) of neural activity; that humans share several of these primary emotion–motivation circuits with other mammals; and that these brain systems evolved to direct behavior (Damasio, 1999; Davidson, 1994; Panksepp, 1998). It is hypothesized that among these primary neural systems are at least three discrete, interrelated emotion–motivation systems in the mammalian brain for mating, reproduction, and parenting: lust, attraction, and attachment (Fisher, 1998).

The sex drive (the libido or lust) is characterized by a craving for sexual gratification and it is associated primarily with the estrogens and androgens.

The attraction system is characterized by increased energy and focused attention on a preferred mating partner. In humans, the attraction system (standardly called romantic love, obsessive love, passionate love, being in love, infatuation, or limerence) is also characterized by feelings of exhilaration, "intrusive thinking" about the love object, and a craving for emotional union with this partner or potential partner. There is some evidence that this affective state is primarily associated with elevated levels of central dopamine (DA) and norepinephrine (NE) and decreased levels of central serotonin (5-HT) (Bartels & Zeki, 2000; Fisher, 1998; Wang et al., 1999).

The adult male–female attachment system, as defined by ethologists, is characterized in birds and mammals by mutual territory defense and/or nest building, mutual feeding and grooming, the maintenance of close proximity,

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separation anxiety, shared parental chores, and other affiliative behaviors. In humans, adult male–female attachment (often called "companionate love") is also characterized by feelings of calm, security, social comfort, and emotional union. The neural circuitry of this brain system has been associated primarily with the neuropeptides, oxytocin and vasopressin (Carter, 1992; Carter, DeVries, & Getz, 1995; see also Pedersen, Caldwell, Jirikowsk, & Insel, 1992; Winslow et al., 1999).

Lust, attraction, and attachment are not only associated with different neurotransmitters and/or hormones; these emotion–motivation systems are also associated with different behavioral repertoires, and they evolved to direct different aspects of reproduction (Fisher, 1998). The sex drive evolved principally to motivate individuals to seek sexual union with *any* appropriate member of the species. The constellation of neural circuits associated with attraction evolved to motivate individuals to select among potential partners or suitors, prefer specific conspecifics, and focus their courtship attention on genetically appropriate individuals, thereby conserving mating time and energy. The neural circuitry for adult male–female attachment evolved primarily to motivate individuals to sustain affiliative connections long enough to complete species-specific parental duties (Fisher, 1998).

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Because different species pursue different reproductive strategies to coordinate their specific ecological and biological needs, the neural correlates of these three emotion–motivation systems can be expected to vary across species. These neural systems are also expected to vary among individuals within a species and across the life course of each individual (Fisher, 1998).

These neural systems also vary by gender. In *Homo sapiens*, for example, the male sex drive is stimulated to a greater degree by visual stimuli than is the female sex drive (Ellis & Symons, 1990); men use visual pornographic materials of every kind more frequently than women do (Laumann, Gagnon, Michael, & Michaels, 1994). Women are more sexually aroused by romantic words, images, and themes in films and stories (Ellis & Symons, 1990). It is also likely that the male sex drive is more constant while the female sex drive is more periodic but more intense; the male sex drive is focused more directly on copulation while the female sex drive is embedded in a wider range of stimuli; and women express more bisexuality than do men (Fisher, 1999)

Gender differences can also be seen in the expression of romantic attraction. Both sexes express romantic love with approximately the same intensity (Hatfield & Rapson, 1996; Tennov, 1979). And both men and women are attracted to partners who are dependable, mature, kind, healthy, smart, educated, sociable, and interested in home and family (Buss, 1994). But there are some gender differences in what men and women find attractive in a mate. Men tend to be more attracted to a partner's physical appearance—particularly signs of youth and beauty (Buss, 1989; Buss, 1994), while women are more inclined to be attracted to men with money, education, and/or position (Buss, 1994).

Men and women also vary in what triggers feelings of attachment, for example, American men are more likely to define emotional closeness as doing things side-by-side; while American women often view intimacy as talking face-to-face (Fowlkes, 1994; Gottman, 1994; Tavris, 1992).

These three emotion–motivation systems regularly act in concert with one another and with other bodily systems (Fisher, 1998). But they can also act independently of one another. In approximately 90% of avian species, for example, individuals form seasonal or lifelong pair-bonds. Yet, in 90% of some 180 species of socially monogamous songbirds, individuals engage in "extra-pair" copulations as well (Black, 1996; Morell, 1998). In these cases, social attachment to one conspecific is expressed in tandem with the expression of attraction and/or the sex drive for different conspecifics.

The independence of these three emotion–motivation systems is also observable in humans. An example is the response of middle-aged men and women who are administered testosterone to increase sexual desire. These individuals subsequently experience increased sexual thoughts and elevated levels of sexual activity (Sherwin & Gelfand, 1987; Sherwin, Gelfand, & Brender, 1985). But they do not report feeling increased romantic passion or increased attachment to this sexual partner. Moreover, men and women can express deep attachment for a long-term spouse or mate, *while* they express attraction for someone else, *while* they feel sex drive in response to visual, verbal, or mental stimuli unrelated to either partner. And men and women can copulate with individuals with whom they are not "in love"; they can be "in love" with someone with whom they have had no sexual contact; and they can feel deeply attached to a mate for whom they feel no sexual desire or romantic passion. Hence, these three emotion–motivation systems—lust, attraction, and attachment—can and often do operate independently of one another in *Homo sapiens*.

Because these three emotion–motivation systems for mating, reproduction, and parenting have been defined elsewhere (see Fisher, 1998, 2000a, 2000b), the remainder of this paper focuses on discussion of romantic attraction, including (1) its primary characteristics; (2) the primary neurotransmitters that the authors hypothesize are associated with this affective state; (3) and the authors'

in-progress investigation, using functional magnetic resonance imaging (fMRI) of the brain, to establish the neural correlates associated with romantic attraction.

METHOD

In Phase I of the investigation of this emotion–motivation circuit, the cross-cultural literature on romantic passion was canvassed. In a survey of 166 societies, anthropologists found evidence of romantic attraction in 147 of them (Jankowiak & Fischer, 1992). People sang love songs, composed romantic verse, performed love magic, carried love charms, and/or brewed love potions. Some eloped. Some committed suicide or homicide because of unrequited love. And in many of these cultures, myths and fables portrayed romantic involvements. No negative evidence appeared. In the balance of these societies (19 cultures), field scientists had simply failed to examine this aspect of daily living. Romantic attraction, it was concluded, is a universal or near-universal human experience (Jankowiak & Fischer, 1992), a conclusion that suggests that romantic attraction is a distinct emotion–motivation system in the hominid brain.

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The currently available American psychological literature was then canvassed and a list of 13 psychophysiological properties often associated with this excitatory state was compiled (see Fisher, 1998; Hatfield & Sprecher, 1986; Harris, 1995; Tennov, 1979). Then these primary psychophysiological characteristics of romantic attraction were compared with the behavioral effects of central dopamine, norepinephrine, and serotonin (Fisher, 1998).

This comparison led to the hypothesis that the affective state of romantic attraction is primarily associated with elevated levels of central dopamine and norepinephrine and decreased levels of central serotonin (Fisher, 1998).

Then 72-item questionnaire was compiled, based on these common properties of romantic attraction and this questionnaire was administered to 437 American and 402 Japanese men and women (Fisher et al., 2002). Preliminary analysis of these data indicates that individuals in these populations expressed the same feelings of romantic attraction as did the populations recorded in the psychological literature. So this questionnaire was subsequently administered (along with several others) to all participants prior to their participation in Phase II of this study which involved fMRI of the brains of individuals who reported that they had "just fallen madly in love."

An important step in understanding the brain chemistry associated with an emotion–motivation system is to identify the major brain regions involved. So Phase II of this project was launched using fMRI of the brain in an attempt to locate the anatomical regions associated with the affective state of romantic attraction.

To establish the protocol for this experiment, 11 female and 3 male volunteers who reported that they had "just fallen madly in love" were asked to answer questionnaires and orally interviewed about their feelings of romantic love. Then these participants used a computer-based response device to indicate the intensity of their current feelings of romantic love while being exposed to a series of stimuli. It was established that feelings of romantic attraction were stimulated most effectively by photographs of the beloved, "thinking back" to specific relationship events, and songs relevant to the relationship (Mashek, Aron, & Fisher, 2000).

These data on the effectiveness of photographs formed the basis of the protocol for Phase II of this project. In this investigation, volunteers who reported that they had "just fallen madly in love" were first administered several questionnaires and orally interviewed to establish the extent of their romantic passion. Appropriate participants were then educated regarding the fMRI procedure and the protocol of the experiment and the brain scanning session was scheduled and completed. Among the tasks that each participant was required to do during the brain scanning process was to look at a photograph of the beloved and a photograph of a familiar individual for whom the subject felt no strong positive or negative feelings. During this 12-min experiment, 3,200 brain images were collected for each participant. These brain scans were then compared, using several statistical methods.

This study is currently in progress. It is predicted that some of the brain regions associated with the feeling of intense romantic attraction will be those with high concentrations of receptor sites for dopamine, norepinephrine, and serotonin.

RESULTS

Data collected during Phase I of this project indicated that there are 13 psychophysiological characteristics commonly associated with romantic attraction and that 5 of these traits correlate with either elevated levels of central dopamine and/or norepinephrine or decreased levels of central serotonin.

1. When someone falls in love, they begin to feel that their beloved is unique; their "love object" takes on "special meaning" (Tennov, 1979). This phenomenon is coupled with the inability to feel romantic passion for more than one person at a time. Elevated concentrations of central dopamine

are associated with exposure to a novel environment as well as with heightened and focused attention (Kiyatkin, 1995; Salamone, 1996; Scatton, D'Angio, Driscoll, & Serrano, 1988; Tassin, Herve, Blanc, & Glowinski, 1980). These parallels suggest that increased levels of central dopamine contribute to the lover's focused attention on the beloved and the lover's tendency to regard the beloved as unique.

2. Individuals reporting feelings of romantic attraction tend to focus their attention on the positive qualities of the beloved and overlook or falsely appraise his/her negative traits (Murray & Holmes, 1997). They also focus on specific events, objects, and other phenomena that they have come to associate with the beloved. In the 72-item questionnaire based on the common properties of romantic love and administered to 437 American and 402 Japanese men and women, 73% of men and 85% of women reported remembering trivial things that the beloved said and did; 83% of men and 90% of women said they replayed these precious moments as they mused (Fisher et al., 2002).

   As mentioned above, increased levels of central dopamine are associated with focused attention. So this tendency to dwell on specific traits of the beloved and specific moments linked with the beloved are additional indications that elevated levels of central dopamine are associated with the feeling of romantic attraction. Because elevated levels of central norepinephrine are associated with increased memory for new stimuli (Griffin & Taylor, 1995), increased levels of central norepinephrine are most likely also involved.

3. Individuals reporting feelings of romantic attraction experience a host of labile psychophysiological responses, including exhilaration, euphoria, increased energy, sleeplessness, loss of appetite, trembling, a pounding heart, and accelerated breathing. Many also report feeling anxiety, panic, and/or fear in the presence of the beloved. They are subject to abrupt mood swings as well. If the relationship suffers a setback, the attracted individual may fall into listlessness, brooding, and feelings of despair.

   Increased concentrations of dopamine in the brain are associated with euphoria, loss of appetite, hyperactivity, increased mental activity, a delay of the onset of fatigue, and a decreased need for sleep, as well as with anxiety, panic, and a fearlike state (Colle & Wise, 1988; Fisher, 1998; Kruk & Pycock, 1991; Post, Weiss, & Pert, 1988; Wise, 1988). Hence, elevated levels of dopamine are a likely agent for the ecstacy, increased energy, sleeplessness, reduced appetite, fear, and anxiety associated with romantic attraction.

   Data on drugs of abuse also suggest that dopamine is an agent in the feeling of romantic attraction. Amphetamines and cocaine elevate concentrations of dopamine in the brain (Wise, 1989, 1996). And these drugs produce the same exhilaration, excessive energy, sleeplessness, and loss of appetite that are characteristic of individuals who report being "in love."

4. In times of adversity, infatuated individuals experience an intensification of romantic attraction. This reaction may also be associated with elevated levels of central dopamine because when a reward is delayed, dopamine-producing neurons in the midbrain increase their productivity (Martin-Soelch et al., 2001; Schultz, 2000).

5. Individuals reporting feelings of romantic attraction think about the beloved obsessively, what is known as "intrusive thinking." Many informants report that they muse about their "love object" over 85% of their waking hours (Tennov, 1979). Intrusive thinking is a form of obsessive behavior and serotonin-reuptake inhibitors are currently the agents of choice in treating most forms of obsessive–compulsive disorder (Flament, Rapoport, & Bert, 1985; Hollander et al., 1988; Thoren, Asberg, & Bertilsson, 1980). These parallels suggest that decreased levels of central serotonin contribute to the intrusive thinking associated with romantic attraction (Fisher, 1998).

   The remaining psychophysiological traits associated with obsessive romantic attraction have not been linked with specific neural systems or neurochemicals.

6. Individuals reporting feelings of romantic attraction regularly exhibit signs of emotional dependency on the relationship, including possessiveness, jealousy, fear of rejection, and separation anxiety.
7. They experience longing for emotional union with the beloved.
8. They feel a powerful sense of empathy toward the beloved and a willingness to sacrifice for him or her.
9. They tend to reorder their daily priorities and/or change their clothing, mannerisms, habits, or values to become available to the beloved.

10. People reporting feelings of romantic attraction experience sexual desire for the beloved, coupled with possessiveness, the drive for sexual exclusivity, and feelings of jealousy if they suspect infidelity. This possessiveness and desire for sexual exclusivity probably evolved for an important purpose: to drive partners to exclude other suitors, thereby insuring that the courtship is not interrupted until insemination has been completed (Fisher, 1998).
11. Yet, for those who are "in love," the craving for emotional union often takes precedence over the desire for sexual union with the beloved. Fifty-eight percent of men and 72% of women in the above-mentioned questionnaire disagreed with the statement, "The best thing about love is sex." And 64% of both sexes disagreed with the statement, "Sex is the most important part of my relationship with. . ."
12. Individuals expressing feelings of romantic attraction commonly report that this passion is involuntary and uncontrollable.
13. Romantic attraction is generally impermanent, unless physical or social barriers inhibit partners from seeing one another regularly.

The complexity of human brain systems and the myriad ecological and cultural forces that contribute to human behavior make analysis of the brain circuitry of romantic attraction difficult. Yet, similarities between some of the above-mentioned psychophysiological properties of romantic attraction and the general properties of central dopamine, norepinephrine, and serotonin suggest that elevated levels of central dopamine and norepinephrine and decreased levels of central serotonin play a role in some aspects of romantic love in humans.

Romantic love takes a variety of graded forms, however, from reciprocated love (associated with fulfillment and ecstacy) to unrequited love (associated with emptiness, anxiety, and despair). So, it is expected that the amounts and ratios of these monoamines (dopamine, norepinephrine, and serotonin) will vary according to the degree of reciprocation by the beloved and many other social, ecological, and psychological factors. It is also expected that the activities of these monoamines will vary in response to the activities of many other emotion–motivation systems in the brain—creating a complex and dynamic system responsible for evoking the affective state of romantic attraction.

Because the authors are currently analyzing the data collected in the above-mentioned fMRI brain imaging project, this paper does not discuss the results. But a similar study of the neural correlates associated with romantic attraction has been completed by another team of scientists (Bartels & Zeki, 2000) and this study suggests that aspects of our above hypotheses are valid.

DISCUSSION

Bartels and Zeki (2000) examined brain activity (using fMRI brain scanning) in 17 participants who reported being deeply in love. During the procedure, these participants viewed photographs of their partners and photographs of three friends. Bartels and Zeki reported that neural activity was restricted to foci in the medial insula, the anterior cingulate cortex, the head of the caudate nucleus, and the putamen. Deactivations occurred in the posterior cingulate gyrus and in the amygdala, as well as in the right prefrontal, parietal, and middle temporal cortices. It was concluded that "a unique network of areas are responsible for evoking this affective state" (Bartels & Zeki, 2000). This conclusion is consistent with our hypothesis that romantic love is associated with a discrete constellation of neural correlates and distinct from the neural systems associated with the other primary mating emotion–motivation systems: lust and attachment.

The study by Bartels and Zeki also gives some indication of one of the neurotransmitters being associated with romantic attraction. It was noted that "dopamine release due to success in a video game has been localized to a broad region in the striatum that overlaps at least with the activity reported here in the putamen" (Bartels & Zeki, 2000, p. 5). This finding suggests that elevated levels of central dopamine play a role in the affective state of romantic attraction, data that is consistent with our hypothesis.

Fisher (1998) hypothesized that human beings exhibit at least three interrelated, yet distinct, emotion–motivation systems for mating, reproduction, and parenting: the sex drive, romantic attraction, and male–female attachment. The sex drive evolved to motivate males and females to copulate with any appropriate partner; romantic attraction evolved to motivate individuals to select among potential mating partners, prefer a specific conspecific, and focus their mating effort on a genetically appropriate individual, thereby conserving mating time and energy. Attachment evolved to enable males and females to tolerate a mate or mates long enough to complete species-specific parental duties. These three emotion–motivation systems are regularly linked (Fisher, 1998), but they can operate independently. Humans can express deep attachment for a long-term partner, while they feel romantic attraction for someone at the office or in their social circle, while

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they feel the sex drive toward stimuli unrelated to either partner.

Perhaps the neural independence of these three emotion–motivation systems evolved to enable ancestral hominids to take advantage of a range of reproductive strategies simultaneously, such as serial or sustained monogamy in conjunction with clandestine romance and/or "extra-pair" copulations (Fisher, 1998). But the neural independence of romantic love undoubtedly also contributes to contemporary worldwide patterns of adultery and divorce, the cross-cultural prevalence of sexual jealousy, stalking, and spousal homicide, and the high incidence of clinical depression associated with rejection in love (Fisher, 1998).

So investigation into the biology of romantic attraction—and how this neural emotion–motivation system interacts with the brain systems for the sex drive and attachment—may contribute understanding of the underlying brain mechanisms associated with several complex contemporary social problems.

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