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Chapter

THE NEUROPSYCHOLOGY OF PASSIONATE LOVE

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ABSTRACT

Throughout history, artists, poets, and writers have been interested in the nature of passionate love, sexual desire, and sexual behavior. In the 1960s, social psychologists and sexologists began the systematic investigation of these complex phenomena (see Berscheid & Hatfield, 1969; Hatfield & Rapson, 1993; Hatfield & Rapson, 2005, for a review of this research). Yet, only recently have neuroscientists and biochemists begun to explore these complex phenomena.

In this entry, we will review what these distinguished theorists and researchers have learned about these processes.

DEFINING PASSIONATE LOVE

Passionate love is a powerful emotional state. It has been defined as:

A state of intense longing for union with another. Passionate love is a complex functional whole including appraisals or appreciations, subjective feelings, expressions, patterned physiological processes, action tendencies, and instrumental behaviors. Reciprocated love (union with the other) is associated with fulfillment and ecstasy. Unrequited love (separation) is associated with feelings of emptiness, anxiety, and despair (Hatfield & Rapson, 1993, p. 5).

People in all cultures recognize the power of passionate love. In South Indian Tamil families, for example, a person who falls head-over-heels in love with another is said to be suffering from *mayakkam*—dizziness, confusion, intoxication, and delusion. The wild hopes and despairs of love are thought to “mix you up” (Trawick, 1990).

I sense my body responding when _____ touches me.	<table border="1"><tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr></table>	1	2	3	4	5	6	7	8	9
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_____ always seems to be on my mind.	<table border="1"><tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr></table>	1	2	3	4	5	6	7	8	9
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I want _____ to know me—my thoughts, my fears, and my hopes.	<table border="1"><tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr></table>	1	2	3	4	5	6	7	8	9
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I eagerly look for signs indicating _____’s desire for me.	<table border="1"><tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr></table>	1	2	3	4	5	6	7	8	9
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I possess a powerful attraction for _____.	<table border="1"><tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr></table>	1	2	3	4	5	6	7	8	9
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I get extremely depressed when things don't go right in my relationship with _____.	<table border="1"><tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr></table>	1	2	3	4	5	6	7	8	9
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	Total: _____									

On this scale, the higher the score, the more wildly in love a person is said to be.

THE NEUROPSYCHOLOGY OF PASSIONATE LOVE

The Ancients

Since antiquity, court physicians and social observers have searched for methods to detect “lovesickness.” In the 2nd century A. D. Appian of Alexandria (1899) recounted this “case history.”

During the last years of his life, King Seleucus, appointed his son Antiochus King of upper Asia in place of himself. Appian notes:

If this seems noble and kingly on his part, even nobler and wiser was his behavior in reference to his son's falling in love and his self-restraint in suffering; for Antiochus was in love with Stratonice, the wife of Seleucus, his own step-mother, who had already borne a child to Seleucus. Recognizing the wickedness of this passion, Antiochus did nothing wrong, nor did he show his feelings, but he fell sick, took to his bed, and longed for death. Nor could the celebrated physician, Erasistratus, who was serving Seleucus at a very high salary, form any diagnosis of his malady. At length, observing his body was free from all the symptoms of disease, he conjectured that this was some condition of the mind, through which the body is often strengthened or weakened by sympathy. Grief, anger, and other passions disclose themselves; love only is concealed by the modest. As Antiochus would confess nothing when the physician asked him in confidence, he took a seat by his side and watched the changes of his body to see how he was affected by each person who entered his room. He found that when others came the patient was all the time weakening and wasting away at a uniform pace, but when Stratonice came to visit him his mind was greatly agitated by the struggles of modesty and conscience, and he remained silent. But his body in spite of himself became more vigorous and lively, and when she went away he became weaker again (pp. 317-318).



Antiochus and Stratonice. In this painting, Jacques-Louis David (1748-1825) depicts the moment in which Erasistratos diagnosed Antiochus' love for his stepmother. École des Beaux-Arts at Paris.

Plutarch (1st century, A.D./1920), more medically oriented, detailed Antiochus' symptoms:

Accordingly, when any one else came in, Antiochus showed no change; but whenever Stratonice came to see him, as she often did, either alone, or with Seleucus, lo, those tell-tale signs of which Sappho sings were all there in him—stammering speech, fiery flashes, darkened vision, sudden sweats, irregular palpitations of the heart, and finally, as his soul was taken by storm, helplessness, stupor, and pallor (pp. 93 and 95).

Appian of Alexandria (1899) continued:

So the physician told Seleucus that his son had an incurable disease. The king was overwhelmed with grief and cried aloud. Then the physician added, "His disease is love, love for a woman, but a hopeless love." (pp. 317-318).

King Seleucus, however, was not one to be stopped by obstacles. Appian of Alexandria (1899) notes:

Seleucus was overjoyed, but it was a difficult matter to persuade his son and not less so to persuade his wife; but he succeeded finally. Then he assembled his army, which was perhaps expecting something of the kind, and told them of his exploits and the extent of his empire, showing that it surpassed that of any of the other successors of Alexander, and saying that as he was now growing old it was hard for him to govern it on account of its size. "I wish," he said, "to divide it and so at the same time to provide for your safety in the future and give a part of it now to those who are dearest to me. It is fitting that all of you, who had advanced to such greatness of dominion and power under me since the time of Alexander, should cooperate with me in everything. The dearest to me, and well worthy to reign, are my grown-up son and my wife. As they are young, I pray they may soon have children to be an ample guarantee to you of the permanency of the dynasty. I will join them in marriage in your presence and will send them to be sovereigns of the upper provinces now. And I charge you that none of the customs of the Persians and other nations is more worthy of observance than this one law, which is common of them, "That what the king ordains is always right." When

he had thus spoken the army shouted that he was the greatest king of all the successors of Alexander and the best father. Seleucus laid the same injunctions on Stratonice and his son, then joined them in marriage, and sent them to their kingdom, showing himself even stronger in this famous act than in his deeds of arms (pp. 319-320).

For a review of the speculations of ancient Greek physicians such as Avicenna, Erasistratos, and Galen, see M.-Marsel Mesulam and J. Perry (1972).

In ancient China, classical scholars possessed a great deal of scientific information about sexual response. For example, the 4th century classic, *Secret Instructions Concerning the Jade Chamber*, provided information concerning the selection of sexual partners, foreplay, and positions for intercourse. The text taught men and women how to identify the stage their partner had reached in the sexual response cycle (Ruan, 1991).

Recently, neuropsychologists have assembled information from neuroanatomical and neurophysiological investigations, ablation experiments, pharmacologic explorations, clinical investigations and behavioral research as to the social psychophysiology of passion. These scientists document that the observations of the ancients are, in part, correct. Passionate love does produce the autonomic nervous system and skeletal-muscular reactions Plutarch and his fellow physicians described (Hatfield & Rapson, 1987; Kaplan, 1979; Liebowitz, 1983.) The early Chinese physicians appear to have been careful observers, too. Their descriptions of the stages of sexual response sound much like those described by Alfred Kinsey and his associates (1948 and 1953) and by William Masters and Virginia Johnson (1966).

The ancients provide a beginning. In spite of the valuable insights that their observations provide, folklore is often wrong-headed or incomplete. Today's neuropsychological research into passionate love and sexual desire makes it clear that men and women's cognitions, emotions, and behaviors interact in ways only dreamed of by early court physicians and scientists.

Modern Day Neuropsychological Explorations into Passionate Love

The Pioneering EEG Research of Niels Birbaumer and his Tübingen colleagues

The first modern-day neuroscientists to study passionate love were Niels Birbaumer and his Tübingen colleagues (1993). These authors argued that cortical processes in imagery do not differ from "actual" processing, storage, and retrieval of information. As part of a larger research project, they interviewed 10 men and women. Participants were asked to complete six different tasks, which ranged from imaging tasks (imagining a time in their past in which they had been joyously in love [without sexual imagery] and imagining the same scene [with sexual imagery]) to sensory tasks (such as determining which of two pieces of sandpaper was the smoothest). The authors observed:

Subjects in love carry their emotional "burden" like a snail's house into the laboratory of the physiologist. The vividness and readiness of their emotional imagery is particularly intense and easy to create under laboratory conditions (p. 133).

While participants performed these tasks, EEG (electroencephalogram) recordings were obtained from 15 different brain locations. The authors discovered (on the basis of their EEG

assessments) that the frontal and posterior groupings showed similar dimensions on the romantic imagery tasks, whereas smaller dimensions were found in the frontal as compared to the posterior electrode sites on the four sensory tasks. The authors concluded that passionate imagery involves a significantly higher brain complexity than does sensory stimulation at all brain sites, but particularly at frontal regions.

In a second experiment, Birbaumer and his group (1993) focused primarily on erotic images—comparing 10 people who were passionately in love (as assessed by the *Passionate Love Scale* described earlier) with a matched group of 10 people who were not emotionally involved with anyone. Participants were asked to imagine a joyous scene with a beloved partner, a scene of intense jealousy, and a neutral scene (an empty living room). During these visualizations, the scientists recorded EEG responses from the midline (Fz, Cz, Pz) and its fractal dimensions were estimated (using the method described by Graf & Elbert, 1988).

On the bases of these analyses, the authors concluded that passionate love is “mental chaos.” Passionate imagery employed anatomically more complex and more widespread (less localized) brain processes than did sensory tasks. Frontal lobe mechanisms, in particular, seemed to add to imagery-related chaos compared to tactile or visual stimulation. Images, they note, may be “more than just pictures in the head” (p. 134).

The authors concluded this preliminary study by calling for more research. It was a full decade before anyone responded to their plea.

2. Recent fMRI Research: Andreas Bartels and Semir Zeki

In 2000, two London neuroscientists, Andreas Bartels and Semir Zeki, attempted to identify the brain regions associated with passionate love and sexual desire. The scientists put up posters around London, advertising for men and women who were “truly, deeply, and madly in love.” They also recruited participants via the internet. Seventy young men and women from 11 countries and several ethnic groups responded. Respondents were asked to write about their feelings of love and to complete the *Passionate Love Scale (PLS)*. Seventeen men and women, ranging in age from 21-37, were selected for the study. Participants were then placed in an fMRI (functional magnetic imagery) scanner. This high-tech scanner constructs an image of the brain in which changes in blood flow (induced by brain activity) are represented as color-coded pixels. Bartels and Zeki (2000) gave each participant a color photograph of their beloved to gaze at, alternating the beloved’s picture with pictures of a trio of casual friends. They then digitally compared the scans taken while the participants viewed their beloved’s picture with those taken while they viewed a friend’s picture, creating images that represented the brain regions that became more (or less) active in both conditions. These images, the researchers argued, revealed the brain regions involved when a person experiences passionate love and/or sexual desire.

Bartels and Zeki discovered that passion sparked increased activity in the brain areas associated with euphoria and reward, and decreased activity in the areas associated with sadness, anxiety, and fear. Activity seemed to be restricted to foci in the *medial insula* and the *anterior cingulate cortex* and, subcortically, in the *caudate nucleus*, and the *putamen*, all bilaterally. Most of the regions that were activated during the experience of romantic love were those that are active when people are under the influence of euphoria-inducing drugs such as opiates or cocaine. Apparently, both passionate love and those drugs activate a “blissed-out” circuit in the brain. The *anterior cingulate cortex* has also been shown to be

active when people view sexually arousing material. This makes sense since passionate love and sexual desire are generally assumed to be tightly linked constructs.

Among the regions where activity decreased during the experience of love were zones previously implicated in the areas of the brain controlling critical thought (i.e., the sort of mental activity involved when people are asked to make social judgments or to “mentalize”—that is, to assess other people’s intentions and emotions.) Such brain areas are also activated when people experience painful emotions such as sadness, anger and fear. The authors argue that once we fall in love with someone, we feel less need to assess critically their character and personality. (In that sense, love may indeed be “blind.”) Deactivations were also observed in the posterior cingulate gyrus and in the amygdala and were right-lateralized in the prefrontal, parietal, and middle temporal cortices. Once again, the authors found passionate love and sexual arousal to be tightly linked.

Not surprisingly, the Bartels and Zeki (2000, 2004) research sparked a cascade of fMRI research.

3. Helen Fisher, Arthur Aron, and Lucy Brown

In *Why We Love*, Helen Fisher (2004) argued that people possess a trio of primary brain systems designed to deal with close, intimate relationships. These are: attraction (passionate love), lust (sexual desire), and attachment (companionate love).¹ Presumably, this trio of systems evolved during humankind’s long evolutionary history; each is designed to play a critical role in courtship, mating, and parenting. In theory, attraction evolved to persuade our ancestors to focus attention on a single favored courtship partner. Sexual desire evolved to motivate young people to seek a *wide range* of sexual partners. Attachment evolved to insure that devoted parents would remain together during the first crucial four years of a child’s life.

According to Fisher (2004) attraction (passionate love) is characterized by a yearning to win a preferred mating partner. She speculated that three chemicals—dopamine, norepinephrine, and serotonin—play a crucial role in romantic passion. *Sexual desire* (lust), on the other hand, is typified by a *general* craving for sexual gratification and may be directed toward many potential partners. In men and women, she observed, the androgens, particularly testosterone, are central to sparking sexual desire. Attachment (companionate love) is comprised of feelings of calm, social comfort, emotional union, and the security felt in the presence of a long-term mate. It sparks affiliative behaviors, the maintenance of close proximity, separation anxiety when closeness disappears, and a willingness to participate in shared parental chores. Animal studies suggest that this brain system is primarily associated with oxytocin and vasopressin in the nucleus accumbens and ventral pallidum.

The Joys of Love

In focusing in on passionate love, Fisher (January 19, 2000) observed:

I speculated that the feelings of euphoria, sleeplessness and loss of appetite as well as the lover’s intense energy, focused attention and increased passion in the face of adversity might all be caused in part by heightened levels of dopamine or norepinephrine in the brain.

¹ You will notice that while most social psychologists (see Hatfield & Rapson, 2005) and neuroscientists such as Birbaumer and his colleagues (1993) and Bartels and Zeki (2004) assume that the emotion of passionate love and sexual desire are closely linked, Fisher (2004) assumes that passionate love and sexual desire are fueled by very different brain systems. We will discuss this theoretical difference in greater length in a later section.

Similarly, I believed that the lover's obsessive thinking about the beloved might be due to decreased brain activity of some type of serotonin. I also knew these three compounds were much more prevalent in some brain regions than in others. If I could establish which regions of the brain become active while one is feeling romantic rapture, that might confirm which primary chemicals are involved (p. 77).

To test these notions, Fisher (2004) and her colleagues Arthur Aron and Lucy Brown (along with graduate students Deborah Mashek and Greg Strong) conducted a series of fMRI studies. "Have you just fallen madly in love?" asked the announcement posted on a bulletin board on the SUNY Stony Brook campus. She received a flood of replies. On the basis of interviews, Fisher selected 17 young lovers. All of these men and women scored high on the *Passionate Love Scale*.

To test her notions, Fisher followed the prototype described by Bartels and Zeki (2000). She asked lovesick men and women to view pictures of their beloved and "a boring acquaintance," while an fMRI imager recorded the activity (blood flow) in their brains.

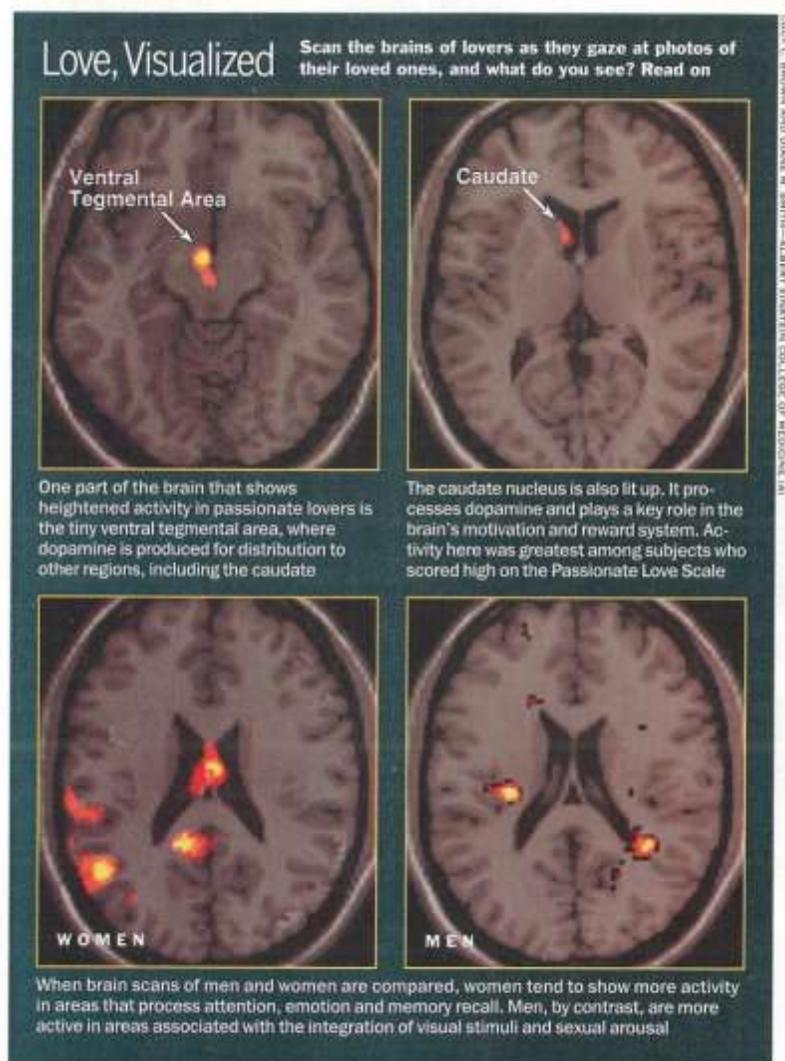
Fisher (January 19, 2004) found that when lovesick men and women gazed at their beloved, activity was sparked in many brain areas. (This should come as no surprise since as Acevedo, et al., 2008; and Carlson & Hatfield, 1992, noted, passionate love is associated with a wider array of related feelings and emotions [guilt, sadness, anger, jealousy, sexual desire, etc.] than is any other basic emotion.) Two areas, were found to be critically important: the caudate nucleus (a large, C-shaped region deep in the center of the brain) and the ventral tegmental area (VTA), a group of neurons at the very center of the brain. "I was astonished," Fisher said. The caudate is "a key part of the brain's 'reward system,' the mind's network for general arousal, sensations of pleasure and the motivation to acquire rewards" (p. 79). The VTA is a central part of the reward circuitry of the brain.

Fisher (January 19, 2004) observed:

I had hypothesized that romantic love is associated with elevated levels of dopamine or norepinephrine. The VTA is a mother lode for dopamine-making cells. With their tentacle-like axons, these nerve cells distribute dopamine to many brain regions, including the caudate nucleus. And as this sprinkler system sends dopamine to various parts of the brain, it produces focused attention as well as fierce energy, concentrated motivation to attain a reward, and feelings of elation—even mania—the core feelings of romantic love.

No wonder lovers talk all night or walk till dawn, write extravagant poetry and self-revealing e-mails, cross continents or oceans to hug for just a weekend, change jobs or lifestyles, even die for one another. Drenched in chemicals that bestow focus, stamina and vigor, and driven by the motivating engine of the brain, lovers succumb to a Herculean courting urge (p. 79).

Lucy Brown added: "That's the area that's also active when a cocaine addict gets an IV injection of cocaine. It's not a craving. It's a high" (Quoted in Blink, 2007, p. 3.)



fMRI pictures of “The Brain in Love.”

Blink (2007) observes:

You see someone, you click, and you're euphoric. And in response, your ventral tegmental area uses chemical messengers such as dopamine, serotonin, and oxytocin to send signals racing to a part of the brain called the nucleus accumbens with the good news, telling it to start craving. [Certain regions] are deactivated—areas as within the amygdala, associated with fear (p. 3).

(For more detailed descriptions of this research, see Aron, et al, 2005; and Fisher, et al, 2005). Fisher (2004) concluded by observing that the chemistry of romantic attraction generally elevates sexual motivation.

Alas, other neuroscientists (such as Bartels & Zeki, 2000, who studied the fMRI responses of joyous lovers), have secured slightly different results than those described by Fisher and her colleagues (2002). (Bartels & Zeki considered (1) passion to be an emotion and (2) found a close connection between passionate love and sexual desire). Fisher speculates that such differences may be due to the fact that while she and her colleagues studied young people who are in the first throes of love of love, her critics have focused on men and women who fell in love some time ago. (Fisher's participants had been in love for an average of seven months; Bartels and Zeki's participants for 2.3 years.) In addition, Fisher studied a homogeneous group of SUNY students, while Bartels and Zeki studied people from different cultural backgrounds and of a variety of ages.

Whether or not these differences adequately account for these differing results is as yet unknown.

The Dark Side of Love: Anger, Sadness, and Misery

Joyous passionate love is only one-half of the equation, of course. Love is often unrequited. What kind of brain activity occurs when passionate lovers are rejected?

In a second study, Fisher and her colleagues (2004) studied 15 men and women who had just been jilted by their beloved. First, they hung a flyer on the SUNY at Stony Brook bulletin board. "Have you just been rejected in love. But can't let go?" Rejected sweethearts were quick to respond. In initial interviews, Fisher found that heartbroken men and women were caught up in a swirl of conflicting emotions—they were still wildly in love, yet feeling abandoned, depressed, angry, and in despair.

But what was going on in their brains? To find out, Fisher and her colleagues (2004) followed the same protocol they'd utilized in testing happily-in-love men and women—i.e., they asked participants to alternately view a photograph of their one-time beloved and a photograph of a familiar, but emotionally neutral individual. The authors found that when contemplating their beloved, rejected lovers displayed greater activity in the right nucleus accumbens/ventral putamen/pallidum, lateral orbitofrontal cortex and anterior insular/operculum cortex than they did when contemplating neutral images. In short, jilted lovers' brains "lit up" in the areas associated with anxiety, pain, and attempts at controlling anger as well as addiction, risk taking, and obsessive/compulsive behaviors. Jilted lovers did, indeed, appear to experience a storm of passion—passionate love, sexual desire, plus anguish, rejection, rage, emptiness, and despair.

Other neuroscientists who have studied the fMRI responses of lovers who are actively grieving over a recent romantic breakup, have secured slightly different results than those secured by Fisher and her colleagues (see Najib, et al., 2004). Fisher (2004) speculates that her critics may have focused on men and women who broke up some time ago and have presumably adapted to their losses. Instead of at the grief stage, they may have been at a subsequent stage in the grieving process—experiencing resignation and despair.

In conclusion: Psychologists' opinions may differ on whether romantic and passionate love are emotions (Shaver, Morgan, & Wu, 1996) or are not emotions (Reis & Aron, 2008) and whether passionate love, sexual desire, and sexual motivation are closely related constructs (psychologically, neurobiologically, and physiologically) (Fehr & Russell, 1991; Hatfield & Rapson, 1987; Hendrick & Hendrick, 1987a; Regan, 1998, 2004) or very different in their nature (Diamond, 2004; Reis & Aron, 2008). In addition, scientists have sharply criticized the widespread use of fMRI techniques to study the nature of love, claiming that

currently the fMRI studies track only superficial changes and lack reliability and validity (Cacioppo, et al., 2003; Movshon, 2006; Panksepp, 2007; Wade, cited in Wargo, 2005). One critic observed: “It’s like the Wild West out there. Scientists are working in uncharted territory; there hasn’t been time for the development of adequate critical standards; and fMRI research has such status, that everything gets published!” (We might also note that although in TV shows like *House*, the administration of fMRIs is an eerily silent procedure, in fact a real fMRI is a ear-splitting and bone shattering process. Participants staggering out the an experimental room often report: “I thought I was going crazy! In spite of my earplugs, the noise was unbelievable. I tried to think of love, but in fact I kept thinking ‘Get me out of here!’” This technological problem may make the interpretation of fMRI studies somewhat problematic.) Nonetheless, this path-breaking research (as it grows ever more sophisticated) has the potential to answer age-old questions as to the nature of culture, love, and human sexuality.

Adrenalin makes the heart grow fonder
—Elaine Hatfield & Ellen Berscheid

Dopamine. God’s little neurotransmitter. Better known by its street name, romantic love.
Also norepinephrine. Street name, infatuation.
—Neely Tucker

THE BIO-CHEMISTRY OF LOVE

Researchers are beginning to learn more about the chemistry of passionate love and a potpourri of related emotions. They are also learning more about the way that various emotions, positive and negative, interact.

The Ancients

A number of researchers have focused on the chemistry of love—searching for (in effect) the elusive “Love potion #9.” In 18th century, London physicians crafted love nostrums and aphrodisiacs from a variety of substances, combining:

... crushed toads, salt of vipers, ground garden snails “bruised to a perfect paste,” *pulvis humani cranum* (powered human skull), “volatile salt of millipedes,” *sal vitrioli* (hydrochloric acid), and copious amount of alcohol (Madeira was favored), rhubarb, and that luckily easily available substance *acqua pluvialis* (rain water) (Hunt, 2000-2001, p. 46.)

Pioneering Research: Michael Liebowitz and Helen Singer Kaplan

Psychiatrist Michael Liebowitz (1983) was one of the first to speculate about the chemistry of love. He argued that passionate love brings on a giddy feeling, comparable to an

amphetamine high. He contended that it was phenylethylamine (PEA), an amphetamine-related compound, that produces the mood-lifting and energizing effects of romantic love. He observed that "love addicts" and drug addicts have a great deal in common: the craving for romance is merely the craving for a particular kind of high. The fact that most romances lose some of their intensity with time, may well be due to normal biological processes.

The crash that follows a breakup is much like amphetamine withdrawal. Liebowitz speculates that there may be a chemical counteractant to lovesickness: MAO (monoamine oxidase) inhibitors may inhibit the breakdown of PEA, thereby "stabilizing" the lovesick.

Liebowitz also offered some speculations about the chemistry of the emotions which criss-cross lovers' consciousness as they plunge from the highs to the lows of love. The "highs" include euphoria, excitement, relaxation, spiritual feelings, and relief. The "lows" include anxiety, terrifying panic attacks, the pain of separation, and the fear of punishment. His speculations were based on the assumption that non-drug and drug highs and lows operate *via* similar changes in brain chemistry.

In excitement, Liebowitz proposed that naturally occurring brain chemicals, similar to the stimulants (such as amphetamine and cocaine), produce the "rush" lovers feel. In relaxation, chemicals related to the narcotics (such as heroin, opium and morphine), tranquilizers (such as Librium and Valium), sedatives (such as barbiturates, Quaaludes and other "downers"), or alcohol, which acts chemically much like the sedatives, and marijuana and other cannabis derivatives, produce a mellow state and wipe out anxiety, loneliness, panic attacks, and depression. In spiritual peak experiences, chemicals similar to the psychedelics (such as LSD, mescaline and psilocybin) produce a sense of beauty, meaningfulness, and timelessness.

In the same era, Helen Singer Kaplan (1979) provided some information as to the chemistry of sexual desire. In both men and women, testosterone (and perhaps LH-RF, luteinizing hormone-releasing factor) are the libido hormones. The neurotransmitter dopamine may act as a stimulant, serotonin or 5-HT (5-hydroxytryptamine) as inhibitors, to the sexual centers of the brain.

Kaplan (1979) observed:

When we are in love, libido is high. Every contact is sensuous, thoughts turn to Eros, and the sexual reflexes work rapidly and well. The presence of the beloved is an aphrodisiac; the smell, sight, sound, and touch of the lover—especially when he/she is excited—are powerful stimuli to sexual desire. In physiologic terms, this may exert a direct physical effect on the neurophysiologic system in the brain which regulates sexual desire. . . . But again, there is no sexual stimulant so powerful, even love, that it cannot be inhibited by fear and pain. (p. 14).

Kaplan ended by observing that a wide array of cognitive and physiological factors shape desire. Although passionate love and the related emotions we have described may be associated with specific chemical neurotransmitters (or with chemicals which increase/decrease the receptors' sensitivity), most emotions have more similarities than differences. Chemically, intense emotions do have much in common. Kaplan reminds us that chemically, love, joy, sexual desire, and excitement, as well as anger, fear, jealousy, and hate, are all intensely arousing. They all produce an ANS sympathetic response. This is evidenced by the symptoms associated with all these emotions—a flushed face, sweaty palms, weak knees, butterflies in the stomach, dizziness, a pounding heart, trembling hands, and accelerated breathing.

For a survey of modern research on the biological substrates of human sexuality, see Hatfield & Berscheid (1971); Hyde (2005); Kauth (2007); and Regan (1999).

Falling in love is a bit like going crazy.
—Donatella Marazziti

Modern Day Neurobiological Research: Donatella Marazziti

Italian psychiatrist Donatella Marazziti (an editor of this collection) has done some of the most intriguing work on the nature of passionate love. In the popular press, one of Marazziti's observations—"Love is insanity"—has sparked intense scientific and journalistic interest.

In the late 1990s, Donatella Marazziti and her colleagues (1999) speculated that passionate lovers and patients suffering from obsessive-compulsive disorders (OCD) might have something in common: both may be lacking in a neurotransmitter (serotonin) that has a soothing effect on the brain. Too little serotonin has been linked to anxiety, depression, and aggression. Drugs in the Prozac family fight these conditions by boosting the chemicals presence in the brain.

To test this notion, the authors selected 20 men and women who were passionately in love, 20 unmedicated OCD patients, and 20 normal controls. Tracking chemicals inside the brain is difficult (to say the least!), so the authors settled on a simple technique: they calculated the amount of serotonin in platelets—tiny cells that are easily retrieved from an ordinary blood sample. The 5-HT transporter was evaluated with the specific binding of ³H-Pparoxetine (³H-Par) to platelet membranes. The results supported Marazziti and her colleagues' notion. The density of ³H-Par bonding sites was indeed significantly lower in lovers and those suffering from OCD disorders than in normal controls (people who were either single or in monogamous, long term relationships) (see also Marazziti & Canale, 2004).

Marazziti and her colleagues (2003) have also investigated the dark side of love—passionate jealousy. The authors selected 21 Italian university students consumed by jealous thoughts, 14 OCD patients (whose main obsession was jealousy), and 21 control subjects, not plagued by jealous concerns. They discovered that men and women who were excessively jealous suffered from a number of psychopathological traits (as well) and produced reduced density of ³H-Par binding compared with their healthy peers.

It was these findings that led the Marazziti group to conclude that love is a kind of insanity.

For additional information, see Marazziti (2005) and chapter 30 in this text.

Odi et amo (I hate and I love)
—Catullus

The Cross-Magnification Process

Scientists have long contended that men and women are most susceptible to passionate love and sexual desire when their lives are turbulent. It is assumed that although each basic emotion has its basic chemical signature that an additional supply of adrenalin and noradrenalin may help fuel the intensity of emotional reactions (Kaplan, 1979; Schachter & Singer, 1962). Social psychologists have called this phenomenon "the cross-magnification process" (Carlson & Hatfield, 1992) or the "excitation transfer process" (Zillmann, 1984).

An array of theorists (Freud, 1953; Reik, 1972), for example, have proposed that it is precisely when people are *not* at their best—when their self-esteem has been shattered, when they are anxious and afraid, when their lives are turbulent and stressful—that they will be especially vulnerable to falling head-over-heels in love. This makes some sense. After all, infants' early attachments (which motivate them to cling tightly to their mother's side in panic when danger threatens and to go their own way when it all is safe) are thought to be the initial prototype of passionate love (Hatfield, Brinton, & Cornelius, 1989; Hatfield, Schmitz, Cornelius, & Rapson, 1988; Hazen & Shaver, 1987).

Several researchers have demonstrated that children and adults are especially prone to seek romantic and sexual ties when they are anxious and/or under stress. In a duo of studies, Hatfield and her Hawaii colleagues (Hatfield, Brinton, & Cornelius, 1989; Hatfield, Schmitz, Cornelius, & Rapson, 1988), for example, found that children and teen-agers who were either momentarily or habitually anxious were especially vulnerable to passionate love. Young people who varied in age from 12 to 16 years of age, and who were of Chinese-, European-, Japanese-, Korean-American, or mixed ancestry, were asked to complete the *Child Anxiety Scale* (Gillis, 1980) or the *State-Trait Anxiety Inventory for Children* (Spielberger, Gorsuch, & Lushene, 1970). These scales were designed to measure both state anxiety (how anxious young people happen to feel at the moment) and trait anxiety (how anxious they generally are). The authors found that children and adolescents who were high on either trait or state anxiety received the highest scores on the *Passionate Love Scale*.

Donald Dutton and Arthur Aron (1974) also tested the notion that anxiety and fear can deepen desire in a series of ingenious experiments. In one experiment, they compared reactions of men who crossed one of two bridges in North Vancouver. The first bridge (the Capilano Canyon Suspension Bridge) is a five-foot wide, 450-foot-long bridge, composed of wood slats and wire cable, which is suspended 230 feet above dangerous rocks and shallow rapids. As people walked over it, the bridge swayed, wobbled, and tilted in a frightening manner. The second bridge was a solid, safe cement structure.

As each young man crossed one of the bridges, a good-looking college woman approached him. She explained that she was doing a class project and asked if he would fill out a questionnaire concerning his attitudes toward conservation. When the man had finished, she offered to explain her project in greater detail. She scribbled her telephone number on a scrap of paper, so he could call her if he wanted more information. Which men called? Nine of the 33 men on the suspension bridge called her; only two of the men on the solid bridge called!

In subsequent years, researchers have collected a great deal of experimental and correlational evidence for the intriguing contention that, under the right conditions, a variety of awkward and painful experiences can deepen passion. These include anxiety and fear (Brehm et al., 1978; Dienstbier, 1978; Hatfield & Rapson, 1996; Hoon et al., 1977; Meston & Frohlich, 2003; Riordan & Tedeschi, 1983), embarrassment (Byrne, Przybyla, & Infantino, 1981), the discomfort of seeing others involved in conflict (Dutton, 1979), jealousy (Clanton & Smith, 1987), loneliness (Peplau & Perlman, 1982), anger (Barclay, 1969 and 1971; Driscoll, Davis, & Lipetz, 1972), horror (White et al., 1981), or even grief.

The End of the Affair

Fisher (2004) closes her analysis of the brain systems sparking attraction, lust, and attachment by observing that passionate attachments are by their nature time-bound. She contends that in the course of evolution our ancestors came to be genetically programmed to meet, mate, and move on—a strategy designed to create optimal genetic variety in the young. When she examined the data from 58 human societies selected from the *Demographic Yearbook of the United Nations*, she discovered that in the majority of societies, couples tended to separate and divorce around the fourth year of marriage. Fisher notes that: (1) many socially monogamous species form pair-bonds that last only long enough to rear the young through infancy; and (2) in hunting/gathering societies, it generally takes four years to rear a child. (Children in such societies join in multi-age play groups soon after being weaned, becoming the responsibility of relatives and older siblings.) (3) Thus she hypothesizes that it may be “natural” for young couples to meet, court, marry, reproduce, and remain together only long enough to raise a child. After that period, the chemistry of attraction (the stew of increased dopamine, decreased serotonin, and increased norepinephrine) swings into action and men and women begin to feel ancient tugs of attraction, sexual desire, and finally attachment yet again.

MAJOR ISSUES

In reviewing this literature, two questions stand out: (1) Is love an emotion? (2) How tightly linked are passionate love and sexual desire? We will close with a final question: (3) How useful are cyber-matching sites based on neuroscience models—like Chemistry.com and ScientificMatch.com?

Is Passionate Love an Emotion?

Most social psychologists would probably agree that passionate love is an emotion.

In a seminal article, Kurt W. Fischer and his colleagues (1990) characterized emotions this way:

Emotions are complex functional wholes including appraisals or appreciations, patterned physiological processes, action tendencies, subjective feelings, expressions, and instrumental behaviours (p. 85).

Scholars have interviewed men and women from a variety of cultures and of different ages. They have conducted surveys and experiments, utilized prototype analyses, and taken a social categorical approach to order to determine whether or not love should be classified as a basic emotion, and if so, what people mean by the terms “in love” and “love.” When Shaver and his colleagues (1996 and 1991) reviewed all the evidence, pro and con, they concluded that love is indeed a basic emotion.

In cross-cultural research—in languages as different as English, Italian, Basque, and Indonesian—ordinary people are able to identify five distinct emotions: love, joy, anger, sadness, and fear—as prototypic emotions. Generally, passionate love is associated with the terms “arousal,” “desire,” “lust,” “passion,” and “infatuation. Companionate love is

associated with “love,” “affection,” “liking,” “attraction,” and “caring” (see Shaver et al., 1987; Shaver, et al., 2001).

After discussing the criteria that various theorists have used to classify emotions, they concluded that given these criteria, love (which includes passionate and companionate love) must be classified as an emotion. They observe:

. . . a number of controversies over the status of love can be resolved by distinguishing between the momentary surge form of love, a basic emotion having properties similar to joy, sadness, fear, etc., and relational love, a bond that develops between people, associated with states that include not only surge love, but many other emotions such as distress and anxiety (p. 81)

In another set of studies, Beverly Fehr and James Russell (1991) used the techniques of prototype analysis to find out how ordinary people classified emotions. They found that throughout the world, men and women generally assume that happiness, love, anger, fear, sadness, and hate are basic emotions. They also discovered that people tend to draw a sharp distinction between passionate love (i.e., “being in love”) and companionate love (i.e., “loving.”) Similar results were secured by Berscheid & Meyers (1996), Fehr (1994), Hatfield & Rapson (1993), Regan (1998); Regan & Berscheid (1999); Regan et al. (1999), among a host of others.

Social psychologists, then, generally assume that love (passionate or companionate) is indeed a basic emotion.

Yet, some scholars have argued that “being in love” and “loving” are *not* emotional experiences. They prefer to call love “a plot” or “script” (as in a story you tell yourself), “a sentiment,” “a feeling,” “a disposition,” a “syndrome,” or “a motivational state.” (For a review of these positions, see Shaver, et al., 1996.) Neuroscientists themselves are sharply divided as to whether or not love is an emotion (see Bartels & Zeki, 2000; Birbaumer, et al., 1996; Hatfield & Rapson, 2008) or is not an emotion (see Diamond, 2003 and 2004; Gonzaga, et al., 2006; Reis & Aron, 2008).

Only subsequent research can answer this question. In part it seems like a semantic question. If forced to hazard a guess, however, we would argue that in the future, love in all its varieties *will* be classified as an emotion. When so many scientists and ordinary people classify love as an emotion, insist they feel the “emotion” of love, and behave emotionally when in love, it may be impossible for scientists to produce a paradigm shift.

What is love? . . . [I end by] confessing that, in the case of romantic love, I don’t really know. If forced against a brick wall to face a firing squad who would shoot if not given the correct answer, I would whisper “It’s about 90% sexual desire as yet not sated.

—Ellen Berscheid

How Tightly Linked Are Passionate Love and Sexual Desire?

Are “passionate love” and “sexual desire” the same thing? Forty years ago, when Ellen Berscheid and I began our research into the nature of love, we weren't certain. Some social commentators insisted that the two were one. In the 18th century French erotic novel *Histoire*

de Dom Bougre, for example, a cynical nun disclosed the true meaning of the expression: “to be in love.” It meant, she said, to be “in lust”:

When one says, the Gentleman . . . is in love with the Lady . . . it is the same thing as saying, the Gentleman . . . saw the Lady . . . the sight of her excited his desire, and he is dying to put his Prick into her Cunt. That's truly what it means (as quoted in Ellrich, 1985, p. 222).

Others insisted that the two were very different. In the 18th century, the Marquis de Sade (1797/1968) violently opposed the equation of love and pleasure:

I do not want a woman to imagine that I owe her anything because I soil myself on top of her . . . I have never believed that from the junction of two bodies could arise the junction of two hearts: I can see great reasons for scorn and disgust in this physical junction, but not a single reason for love (p. 148).

In the Victorian era, romantic love was considered to be a delicate, spiritual feeling—the antithesis of crude, animal lust. Freudians, of course, mocked such pretensions. They irritated romantics by insisting that chaste love was simply a sublimated form of carnal love, which lay bubbling just below the surface.

What about today? In the West, most college students make a sharp distinction between “being in love” (which embodies sexual feelings) and “loving” someone (which is not necessarily associated with sexual desire). Ellen Berscheid and her colleagues (Meyers & Berscheid, 1995) found that most students assumed that although you could “love” someone platonically, you could only be “in love” with someone you were sexually attracted to and desired sexually. They concluded: “Thus, our findings suggest that although sexuality may not be a central feature of love, it is most definitely a central feature of the state of being in love” (p. 24). In a national survey, Andrew Greeley (1991) interviewed newly married couples who said they were still in the “falling in love” stage of marriage. He found that passionate love is a highly sexual state. He described the falling in love stage of marriage this way:

When one is in love, one is absorbed, preoccupied, tense and intense, and filled with a sexual longing which permeates the rest of existence, making it both glorious and exhausting . . . Those who are falling in love seem truly to be by love possessed (pp. 122-124).

In the end, Ellen Berscheid and I concluded that passionate love and sexual desire were “kissing cousins.” Passionate love was defined as “a longing for union” while sexual desire was defined as “a longing for *sexual* union” (Hatfield & Rapson, 1987).

Today, this debate seems settled. As Susan and Clyde Hendrick (1987b) noted:

It is apparent to us that trying to separate love from sexuality is like trying to separate fraternal twins: they are certainly not identical, but, nevertheless, they are strongly bonded. . . . Love and sexuality are strongly linked to each other and to both the physical and spiritual aspects of the human condition. For romantic personal relationships, sexual love and loving sexuality may well represent intimacy at its best (pp. 282 and 293).

There is abundant social psychological evidence in support of the contention that in most people's minds, love and sex are tightly related—in fact, most people find it hard to imagine passionate love absent sexual desire (Hatfield & Rapson, 2005; Regan et al., 1999, 2004; Regan & Berscheid, 1999; Ridge & Berscheid, 1989). (Naturally, men and women can easily imagine the converse—sexual desire without passionate love.) As Pamela Regan (2004) observes:

Theoretical discourse from a number of disciplines suggest that sexual desire is a distinguishing feature of the passionate love experience . . . Empirical research substantiates this hypothesis. People believe that sexual desire is part and parcel of the state of being in love, assume that couples who desire each other sexually are also passionately in love, and report a similar association when reflecting on their own dating relationships (p. 115).

Of course, culture surely has a powerful impact on how likely young couples are to link passionate love, sexual desire, and sexual *expression* (Hatfield & Rapson, 2005). Many men, for example, are taught to separate sex and love, while many women are taught to connect the two. The different meanings attributed to sexual activity have been known to cause lovers much distress (Hatfield & Rapson, 2006).

Neuroscientists and evolutionary psychologists, however, are still in sharp disagreement as to whether love and lust are very different systems (Diamond, 2003 and 2004; Gonzaga, et al., 2006) or are tightly linked (Bartels & Zeki, 2000). These neuroscientists do agree, however, that all of the brain systems for passionate love, sexual desire, and attachment do in fact communicate and coordinate with one another.

When the dust settles, we suspect neuropsychologists will come to acknowledge that although love and lust may possess a few distinct features, they are tightly linked. It is hard to imagine that two phenomena so linked in the public mind could be such disparate entities. Thus, the contention that love and sexual desire are “kissing cousins” seems to be an appropriate one.

The Commercialization of Love and Sex Research: The BusinessofLove.com.

Any time a new form of communication is invented—the penny newspaper, Morse code and the telegraph, the ham-radio, TV, or computers—men and women find ways to use that technology to find love. In the 1950s, for example, almost as soon as computers appeared, commercial matchmaking services sprang up (CBC Archives, 1957). Recognized as the first widespread computer matching service was Operation Match, which was created in the mid 1960s by Harvard students after a discussion of the evils of blind dates and mixers. They distributed thousands of questionnaires to college students at several universities and asked them to rate themselves on looks, intelligence, and other dimensions and also to indicate what they would desire in a partner on these same dimensions. In return for the completed questionnaire and a fee of three dollars, they were promised a list of compatible matches. Data were entered on punch cards and analyzed with an Avco #1790 computer (which was probably the size of a small room). According to media reports, it took the computer six weeks to generate the lists. Not surprisingly, the business failed miserably (for a description of this experiment, see Leonhardt, 2006).

Today, while some sites, such as Match.com, are designed for the general population of singles, other sites target special niches of the population. There are those designed to appeal to various age groups (HookUp.com, SilverSingles.com), political groups (ConservativeMatch.com, LiberalHearts.com), religious groups (CatholicSingles.com, ChristianCafe.com, HappyBuddhist.com, Jdate.com), and sexual orientation (GayWired.com, superEva.com). Dating sites also exist for people who possess mental and physical disabilities, unusual sexual preferences, and so forth. Even people who wish to find dates for themselves and their favorite pets can sign on to a site (DateMyPet.com). At the time this chapter was written, there had sprung up almost 1,000 dating websites servicing the U.S. (e.g., Thompson, Zimbardo, & Hutchinson, 2005), and the technology available to create another one in an afternoon.

Recently, neuroscientists and biochemists have joined the gold rush. They have set up sites like ScientificMatch.com (people are matched on the basis of DNA) or Chemistry.com, where scientists use indicators (such as finger length) to classify and match up people, among a host of others.

What scientific principles are being used to match people on the major relationship websites, such as eHarmony.com and Perfectmatch.com? Or on the “scientific” websites? Do people sign up for these services just for fun or do they truly believe that scientists can match them with their ideal Prince Charming or Sleeping Beauty?

Almost all of the sites make fantastic claims. ScientificMatch.com, for example, promises:

DNA Matching and the Magic of Chemistry

When you share chemistry with someone, you significantly increase your chances of realizing these amazing benefits:

1. You’ll love their natural body fragrance—they’ll smell “sexier” than other people.
2. You’ll have a more satisfying sex life.
3. If you’re a woman, you’ll have a higher rate of orgasms.
4. There will be less cheating in your exclusive relationship.
5. As a couple, you’ll be more fertile.
6. Your children will be healthier.

In support of these contentions, the authors cite a slew of articles published in prestigious social psychological, neuroscience, evolutionary psychology, and neurobiochemistry journals.

The more popular Chemistry.com asks men and women to answer 56 questions—things like: “Which image most closely matches your right hand?” The assumption is that people possess different levels of dopamine, serotonin, estrogen, and testosterone. The scholars assume that these differences in brain chemistry have a powerful effect on people’s personalities—determining which of four categories they fit: the explorer, the builder, the negotiator, and the director. (The site attempts to tell people what type (or combination of types) they are, based on physical characteristics (i.e., finger length, etc.)

For common folk, computer matching sites have the imprimatur of Science (with a capital S). In the scientific community there are mixed reactions to claims such as those made by Science.com. Some argue that no one takes the claims of these sites seriously. People access the sites in fun. Besides, such sites give people that are shy or live in geographical

locations or work at jobs that make it difficult to find partners (particularly those who share their values and interests) can access the web to meet dates and mates that might never come their way.

They also point out that commercial matching services are still in their infancy. Since social psychologists, neuroscientists, and neurobiologists are working for these sites, in time—given the money that is being lavished on these commercial enterprises—it is reasonable to hope that in the future, the BusinessofLove.com sites will craft more complex versions of relationship science to inform their questionnaire construction, website construction, and matching algorithms. Thus, in time these matching sites will provide increased opportunities for men and women to find dating and marital relationships that are fulfilling.

Other scientists cringe, arguing that these sites can't possibly fulfill their promises of the perfect match. Currently, these matching sites—arguing that they are businesses not scientific enterprises—are reluctant to explain in any detail how they match people and how successful such matches are.

Critics point out that only charlatans, crooks, and con men sell “elixirs” that cure nothing. People who join these sites looking for love are being cheated. Worse yet, false claims make people who get burned skeptical about the scientific enterprise itself. When people are disappointed—and they are bound to be—they will blame science for their disappointment (see Sprecher, et al, 2008, for a longer discussion of these issues.)

Our personal opinion is that an appreciation of science and its methods is a fragile blossom, easily trampled underfoot, and that scientists participating in these commercial enterprises should tread with care. They can potentially inflict serious damage to the whole neuroscientific enterprise when they promise what they cannot deliver. Love may be wonderful or painful because it is no simple matter.

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