Love and Romance: A Biochemical Approach

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Almost every human being who has experienced love and romance would agree that love is as much about joy as it is about anguish. Indeed, while romantic passion induces indescribable feelings of euphoria and tenderness when one's love is returned, it can also trigger feelings of debilitating anxiety, despair and even rage when one's love is not reciprocated. These feelings are so compelling that love-possessed people have even died and killed for love. Why romantic love creates such emotional and behavioral havoc is a question that researchers have tried to answer by examining the biochemical processes of the brain in love.

Researchers concur that romantic love usually acts in unison with two other primary emotion systems - sexual desire and attachment. These three emotion systems can however act independently of one another: each addresses a specific evolutionary purpose in reproduction, and each involves a distinct biochemical process. Sexual desire, the craving for sexual gratification, has evolved in the context of arbitrary sexual mating and is primarily associated with the "hormone of desire" testosterone. Romantic love, that feeling of being "swept away," has evolved in the context of selective mating and is linked to elevated levels of the natural stimulant dopamine and reduced levels of the neurochemical serotonin. Attachment, marked by feelings of dependability and warmth, has evolved in the context of couple bonding and is related to the "cuddle chemicals" oxytocin in women and vasopressin in men. Although oftentimes romantic love grows into attachment, sometimes it ends in rejection. Unrequited love, the agony of rejection, is also assumed to have an evolutionary origin and specific biochemical characteristics. It is the purpose of this paper to detail the biochemical activity associated with each of the four emotion systems – sexual desire, romance, attachment and unrequited love - and to report on the possible interactions among them.

Sexual Desire

Sexual desire, otherwise known as lust, the libido or the craving for sexual gratification, corresponds to a specific brain circuit that communicates with the reproductive organs and has evolved to initiate the mating process. According to evolutionary psychologist Helen Fisher (2004), sexual desire serves the evolutionary purpose of motivating men and women to "seek sexual union with almost any semi-appropriate partner" (p.78). It activates parts of the brain, such as the limbic and paralimbic structures, associated with sex drive and sexual expression. The moment individuals find someone sexually attractive, the limbic system sends chemical messages to the reproductive organs to start releasing the sex hormone testosterone and to a lesser degree estrogen (Arnow, 2002).

The increase in sexual activity in both men and women as a result of elevated levels of testosterone is well documented. Male athletes who inject testosterone to increase their endurance have more sexual fantasies, erections and orgasms (Fisher, 2004). In one study, testosterone replacement therapy significantly enhanced sexual functioning in 227 men with testosterone deficiency (Wang, Swedloff, Iranmanesh, Dobs & Snyder, 2000). The same therapy proved to have beneficial effects on the sexuality of 61 perimenopausal and postmenopausal women. The women reported major improvements in six aspects of sexuality: sexual satisfaction, sexual pleasure, sexual fantasy, sexual activity, sexual interest, and ability to reach orgasm (Davis, 2003). Another piece of evidence that supports the testosterone-sexual desire link comes from an experiment on the chemistry of sexual behavior, which was broadcast on the ABC TV program *Love Trap* (Watson, 2004). In this experiment, the female participants who displayed the most noticeable mating behavior had 300% more testosterone in their saliva than the other females.

Evolutionary geneticist David Briscoe commented on the same ABC program that the nose is as important as the brain in determining our mating behavior: "… recently we've discovered that there is an organ in the nose which isn't part of the general sense of smell and it seems to be very specifically involved in detecting sex-signaling molecules," the so-called pheromones or naturally scented molecules released by skin (Watson, 2004). It appears that humans inherit the ability to pick up on pheromones for which they have a particular sexual affinity. In one experiment, 49 unmarried women who sniffed boxes containing T-shirts worn by men on two consecutive days were asked to chose the one they would prefer "if they had to smell it all the time" (McClintock, Zelano & Ober, 2002). The women preferred the odor of men with an intermediate level of genetic difference, not identical and not completely dissimilar. The evolutionary explanation for this finding is that mating with somebody genetically similar poses the risk of passing on recessive genetic disorders, whereas mating with somebody totally different may lead to the loss of desirable gene combinations. After all, it appears that the onset of sexual desire is not completely arbitrary; humans do have inbuilt biological mechanisms to detect at least what Dr. Fisher calls "semi-appropriate" mates.

Romantic Love

Regardless of how much lust one feels towards a mate, lust does not necessarily make one feel the exhausting obsessive euphoria that characterizes romantic love. From an evolutionary perspective, romantic love has evolved to "facilitate mate choice, enabling individuals to select between potential mating partners and focus their attention on genetically superior individuals" (Fisher, 2000, p.96). Wasting mating energy on unsuitable partners is not the intent of nature. This makes sense when one thinks of the energy-consuming symptoms of love-smitten people: exhilaration, sleeplessness, loss of appetite, obsessive thinking, and extreme

mood changes. These symptoms may be partially explained by the brain scans and neurochemical activity of love-struck people.

Brain scan findings of in-love individuals have established a link between romantic feelings and increased activity in dopamine-related parts of the brain. Bartels and Zeki (2000) examined the MRI brain images of 17 "madly in love" men and women while they were gazing in rapture at pictures of their adored ones. The MRI images showed increased blood flow in the caudate nucleus, a central brain region associated with addictive behaviors and flooded with the neurochemical dopamine. A rise in dopamine levels is known to produce exhilaration, increased energy (decreased need for sleep) and even mania – the quintessential symptoms of romantic love, but also of opium, heroin, and cocaine use. An unexpected finding reported by Bartels and Zeki (2000) was that in two other parts of the brain, the amygdala and the right prefrontal cortex, the neural activity was markedly suppressed. Given that both brain parts are associated with negative feelings – fear, anger and depression – the researchers interpreted the finding as a possible scientific basis for why the love-struck overlook the negative traits of the beloved. In a similar experiment involving 20 in-love participants, Dr. Fisher (2004) identified elevated blood flow in the same caudate nucleus region and one related brain region, the ventral tegmental, which produces and sends dopamine cells to other brain areas, including the caudate nucleus. In addition, correlations between the participants' scores on the Passionate Love Scale and their MRI results indicated that the more passionate a participant reported to be, the higher his/her brain activity.

Another neurochemical that may deepen our understanding of romantic love is serotonin: while the romance intoxicant dopamine may explain the highs of romantic love, serotonin may shed light on why the love-bitten cannot stop thinking about the beloved. In a survey of 437

infatuated Americans and 402 infatuated Japanese, 79% men and 78% women reported that regardless of where they were, "their mind returned continually to their beloved" (Fisher, 2004, p.9). Low levels of serotonin have been linked to anxiety, depression and obsession. For example, in one study (Marazziti, Akiskal, Rossi & Cassano, 1999) blood tests of 20 men and women who had recently fallen in love were compared to blood tests of 20 others who were not in love and to blood tests of 20 patients who suffered from obsessive compulsive disorder (OCD). OCD is a condition whose main symptoms are an intense desire to think the same thought (obsession) and a compelling need to perform the same action over and over again (compulsion). People with OCD have unusually low levels of serotonin. The blood test comparison confirmed that both the in-love students and the OCD patients had similarly reduced levels of a serotonin-related protein. The in-love students were also found to have serotonin levels 40% lower than their peers. This study provides evidence that the incessant thinking of romantic love is linked to serotonin depletion.

The biochemical picture of romantic love becomes even more complex when looking at the interaction between serotonin and dopamine. Dr. Fisher (2004) explains what may happen if serotonin becomes abnormally low. While reduction in serotonin can drive up dopamine, the rushing dopamine may aggravate romance symptoms, including intrusive thinking, which in turn may reduce serotonin. This inverse relationship between serotonin and dopamine is a central finding of animal experiments that have tested the effects of serotonin-enhancing antidepressants (e.g., Prozac and Celexa). Such antidepressants treat depression by keeping serotonin longer in the brain. In one experiment, the dopamine levels in rats that had been given Prozac dropped by 57% (Glenmullen, 2000). A similar drop in dopamine (50%) was reported in an experiment that measured the neurochemical effects of the new serotonin booster Celexa in rats and baboons

(Glennullen, 2000). The negative serotonin-dopamine relationship is also evident in people who take serotonin-enhancing antidepressants. Since high dopamine and low serotonin are known to fuel romantic feelings, individuals with a chemical profile of low dopamine and high serotonin, as the one produced by antidepressants, are expected to experience weakening of romantic feelings. Indeed, although the efficacy of serotonin boosters in alleviating depressive symptoms is undeniable, so is their ability to jeopardize romantic love by blunting emotions, dampening sexual desire and inhibiting orgasm, according to patients' reports (O'Connor, 2004).

Another interaction takes place between dopamine and testosterone. Dr. Fisher (2004) speculates on the findings from animal and human studies that show a positive relationship between dopamine and testosterone. She believes that this relationship proves that romantic love (stimulated by dopamine) ignites sexual desire (driven by testosterone). This makes sense when considering the amount of time lovers spend kissing, caressing, and cuddling. However, sexual desire does not always trigger passionate love. Men and women who take testosterone report improved sexuality, but they do not become romantically involved with their sex partners. This does not mean that sexual desire can never lead to romance. Since testosterone is known to heighten levels of dopamine, Dr. Fisher's advice is to avoid copulating "with someone with whom you don't wish to become involved. Although you intend to have casual sex, you might just fall in love" (Fisher, 2004, p.85).

Attachment

If mad romantic passion were meant to last forever, many lovers would succumb to emotional and sexual exhaustion. It appears that as passion recedes, attachment grows – the calm, security, companionship and emotional union that long-term committed couples enjoy. From an evolutionary perspective, unlike romantic love, which has evolved to ensure that men

and women select appropriate partners to whom they are faithful until procreation happens, attachment has evolved to ensure that a couple bonds long enough to raise their offspring together (Fisher, 2000).

The two "cuddle chemicals" that make people feel binding attachment are oxytocin, which is present in all female mammals, and vasopressin, which is present in both but more in male than in female mammals. The two chemicals are produced in the hypothalamus and the gonads. Much of the evidence that links attachment to oxytocin and vasopressin comes from studies on prairie voles, a species of small rodents known to be monogamous (Sinha, 2002). When female voles were dosed with oxytocin, they instantly bonded to their partners once they had paired. Unlike the untreated female voles, they rejected strangers and displayed attachment behaviors, such as licking and cuddling, towards their mates. However, as soon as they were injected with a chemical that blocked the release of oxytocin, they abandoned their mates. A similar effect that oxytocin had on female voles was noticed when vasopressin was injected in the brains of male voles. The dosed male voles became at once more territorial, more possessive and more protective of their mates. These behaviors disappeared instantly when the vasopressin-blocking chemical kicked in: after copulation, the male voles deserted their mates only to seek another mating opportunity. In both animals and humans, oxytocin and vasopressin plummet dramatically during sexual arousal and orgasm.

The chemistry of attachment can interfere with that of sexual desire. It seems that the chemical equilibrium that allows for attachment to be accompanied by untiring sexual desire is very unsteady. There is substantial evidence of an inverse relationship between the "two cuddle chemicals" and testosterone (Geary & Flinn, 2002). This explains why long-term committed couples exhibit declining sexual behavior (Burnham, Flynn, Chapman & Gray, 2003) and why

expectant fathers become less interested in sexual intercourse as the attachment to the family intensifies (Berg & Wynne-Edwards, 2001). It also explains why in one experiment the fathers who responded with concern to their infants' distress and desired to comfort them had lower levels of testosterone than did the unconcerned fathers (Berg & Wynne-Edwards, 2001).

The romance chemicals dopamine and serotonin are also affected when oxytocin and vasopressin kick in. High levels of the "cuddle chemicals" may reduce the stimulatory impact of dopamine (Fisher, 2004). Indeed, many long-term affiliated couples can testify that as attachment sets in, romance wanes. Serotonin also swells back to normal levels after a while. This is what happened with the in-love students in Marazziti's experiment (1999) when their serotonin concentrations were retested 12 to 18 months later. The researchers inferred that passionate love commonly lasts anywhere between 6 and 18 months. Dr. Fisher (2002) agreed that romantic love stays vibrant for about one year unless adversity intervenes, in which case the fire keeps burning. Shakespeare's *Romeo and Juliet* is a classic example of love thriving on adversity. In the absence of obstacles, romantic love either wears off as attachment sets in or comes to a bitter end.

Unrequited Love

Waning romance is a small price to pay when compared to the ordeal that unrequited lovers endure. A survey of college students found that only a lucky minority (7%) of men and women had not been deserted by someone they loved (Fisher, 2004). Emptiness, despair, panic, and rage are the core feelings of unrequited love. In an ongoing study conducted by Dr. Fisher (2004), volunteers who had been rejected and were in "excruciating psychological pain" agreed to be surveyed and have their brains scanned (p.154). Even though the experiment is still in

progress, the team conducted by Dr. Fisher collected sufficient data to begin to understand the chemistry of unrequited love.

Dr. Fisher suggests that the neurochemical changes in the brains of people whose love is not returned may explain two important symptoms: separation anxiety and abandonment rage. Separation anxiety, generated by the panic system, sets in motion the stress system and its attendant hormone cortisol. In turn, short-term stress is known to boost dopamine levels and suppress serotonin, the very chemicals that deepen romance. Perhaps that is why rejected lovers feel even more passionate despite pitching anguish, causing them to intensify their efforts to reunite with the beloved.

Abandonment rage - that violent hatred many rejected people feel even when the separation happens in amicable terms – switches on the amygdala, a brain region associated with anger and fear. Because the amygdala is closely connected to centers in the prefrontal cortex that process reward expectation, it comes as no surprise that the rejected burst with rage when they realize that the beloved is unattainable. Since angry behavior would rather drive away than win back one, what evolutionary purpose does the rage of abandonment serves? One assumption is that rage helps rejected lovers to "*extricate* themselves from dead-end matches, lick their wounds, and resume their quest for love in greener pastures" (Fisher, 2004, p. 166). Nature does not want people to waste precious time on mates that are unsuited for procreation or for rearing children.

Concluding Comments

Scientific and anecdotal evidence exists to conclude that the three primary human emotion systems have overlapping, yet distinct, evolutionary origins and chemical correlates in the brain. The overlap is apparent in couples whose craving for each other is as much sexual as it

is emotional, whereas the distinction can be observed in individuals who are able to love more than one person at a time: one can feel deeply attached to a long-term partner while feeling strongly romantic about a second person, while feeling sexually driven towards a third person. Evolutionary scientists say that to love more than one person at a time is possible because love runs through three distinct neurochemical pathways that have evolved to increase humans' chances to propagate the species: as the mating opportunities increase, so do the chances of reproduction. Likewise, the brain circuits for separation anxiety and abandonment rage have evolved to hasten the end of a wasteful relationship and to set rejected lovers on the road to finding more appropriate partners for mating and raising children. Yet, brain chemistry and love share only an associative relationship. A causal relationship would be difficult to establish in view of the multitude of social, cultural and emotional factors that determine when, where, how and why humans select that special someone. After all, the ways of love are still mysterious.

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