YOUR BRAIN ON LOVE: THE THREE STAGES TO EUPHORIA

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Abstract

Romantic love is a three staged phenomenon including lust, attraction, and attachment. It involves a myriad of neurotransmitters meant to improve biological and cultural evolution by biochemically altering emotion and behavior. Important neurotransmitters and hormones include sex steroids, norepinephrine, dopamine, oxytocin, serotonin, and vasopressin. The responses involve a constellation of brain pathways, and, for example, the lower limbic brain regulates reward, motivation, sex, and parenting. In addition, other factors include major histocompatibility complex (MHC) proteins and pheromones for attracting mates with well-matched immunity types, nerve growth factor (NGF) playing a part in bonding, and the autonomic nervous system, fight or flight and rest and digest, respectively composed of the sympathetic and parasympathetic responses.

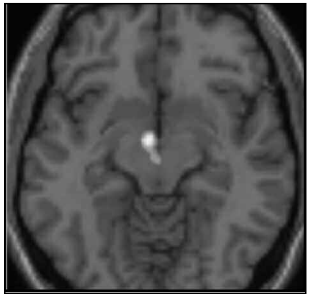
Introduction

Love is composed of a complex array of neurobiological responses that provides an important motivation to reproduce for the survival of a species. Some of the first things written down in history, after trade, laws, and complaining about kings, were poems professing love for a mate (Aron, 2005). Love reduces the ability to judge emotions, critical thinking, and trustworthiness. It bypasses the cognitive ability of the brain, and this is the state of otherworldly emotion called "happiness."

Three Stages

MRI of Dopamine Pleasure Center

Romantic love is the best-characterized type of love in humans as it leads to the most acute changes in the brain. While "motherly" love is strong and forms very close bonds, it is not as acute physiologically as romantic love. Additionally, higher levels of stress and the related neurotransmitters, brain signal chemicals, cause the roller coaster of romantic love. This stress and relaxation cycle may result in increased social bonding and contact (Esch, 2005). Importantly, with the advent of brain imaging tools, modern molecular biology, and the production of synthetic hormones, neurobiology has become a science. MRI imaging has allowed the visualization of brain activity due to certain influences such as love at different stages. The injection of various hormones or neurotransmitters has produced experimental effects showing the function of individual chem-



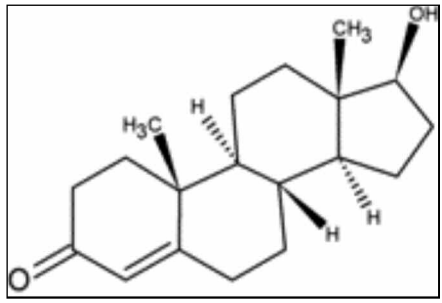
icals on the brain. These chemicals control emotion and behavior.

Neurotransmitters and hormones involved in love include testosterone and the sex steroids in lust, monoamines such as dopamine, norepinephrine, and serotonin in pleasure, attraction, anxiety, and alertness, and finally the peptides oxytocin and vasopressin in forming lasting bonds and attachment. However, individual and gender specific differences do exist in the pathways and forms of stimulus. There are enormous neurobiological similarities and interconnectedness, but still differences and independence between the early stages of romantic love and the later stages of attachment and bonding. Specifically, lust motivates copulation with any partner, attraction causes selection among possible partners saving energy and time, and attachment connects two individuals in bonding to complete parental duties. In terms of neurobiology, romantic love involves three stages including lust, attraction, and lastly, attachment (Fisher, 2002).

Lust

Lust, one of the most notorious of the seven deadly sins, is the libido of mammalian sex drive. At the advent of puberty, it causes the first feelings of desire for sex with any other compatible individual (Fisher, 2002). Both males and females secrete the sex steroid testosterone, which is the main factor in creating sexual drive. Males have more testosterone, as it is part of what makes a male male. However, females secrete some testos-

Testosterone



terone from their adrenal glands. Injecting testosterone into middle-aged males and females increases sex drive but plays no role in romantic feelings or attachment to a partner. Hence, testosterone functions to increase thoughts about sex and sexual activity independent of attraction and attachment in later stages of love. In males, visual stimuli are the strongest producers of arousal while females respond to romantic themes. Male libido is more constant while the female libido occurs in more intense but periodical cycles (Fisher, 2002). On the other hand, these differences may not just be from biological actions. Cultural, religious, and psychological factors may play a role in controlling gender roles and sexual impulses.

Arousal and Motivation

Arousal itself has multiple types including central, involving the brain and spinal cord, peripheral non-genital, involving the autonomic nervous system, and genital arousal, involving erection and lubrication in males and females respectively. Arousal itself seems to connect to the actions of nitric oxide and various neurotransmitters. The amygdala, in the lower brain, processes the meaning of sexual stimulus. Depending on prior memories of abuse or positive experiences stored in the hippocampus, along with pathways involving the dopamine pleasure center, the arousal stimulus will be positive or negative. A positive result will cause sexual arousal, while a negative result will block arousal (Graziottin, 2004). The positive and negative results, pleasure and pain, are closely related in the brain centers involved. Whether there is an appetite or aversion toward a situation directs motivation. Over the time of evolution, pleasure, or beneception, facilitate survival while pain, or nociception, may have undesirable consequences to biology. Dopamine, the neurotransmitter of pleasure, controls whether an experience will be

pleasurable or painful, and an individual will be more likely to repeat a pleasurable event (Esch, 2005).

Attraction

Attraction, the most confusing and complex of all stages of love, is the most stressful, yet exhilarating, of all. In fact, attraction during sexual thoughts and arousal can cause heart arrhythmia due to massive sympathetic nervous system action in the brain and body (Esch, 2005). Men and women are attracted to mature, healthy, educated, and kind individuals. However, men are more likely to be attracted to youth and beauty, while women are more attracted to money, education, or power. The focus and energy associated with attraction create obsessive love, passion, reflection about love, and emotional desire to be with the partner. The people in this early stage of love are "love struck, blinded by love, or infatuated." The most important chemicals in this stage are dopamine, higher in pleasure, norepinephrine, higher in the sympathetic nervous response, and serotonin, lower in romantic stress rather than the normal level in the relaxed state (Fisher, 2002).

Your brain on drugs?

Behavioral effects of romantic love are similar to the actions of a cocaine high, including exhilaration, energy, sleeplessness, and loss of appetite. Cocaine and romantic love both act on the dopamine and opiod-rich center of the brain that controls pleasure. Unlike addictive drugs, however, romantic love has a lead-up period and a let-down period, instead of immediate effects. Dopamine regulates pleasure when induced by mate preference in female prairie voles. When a dopamine inhibitor is infused into the brain, the vole will prefer the male that is around at the point of infusion rather than the pre-

ferred male (Aron, 2005). Whether love is reciprocated or not creates the amount and type of neurotransmitter response. Reciprocated love will include exhilaration and drug-like ecstasy, while unreciprocated love will lead to despair, stress, and emptiness. However, many different cultural factors control brain chemistry balance due to additional reasons outside love or certain events (Fisher, 2002).

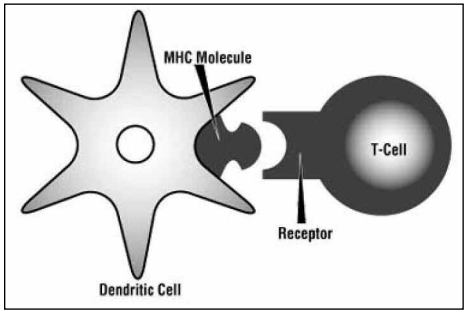
Autonomic Nervous System Response

The autonomic nervous system is important in producing reflexes and physiological changes to help an organism survive. It has two branches, the sympathetic, fight or flight response, and the parasympathetic, rest and digest response. Outside of the brain, the sympathetic nervous system uses norepinephrine to produce change while the parasympathetic nervous system uses acetylcholine. In different tissues, there are different effects. In terms of love, the sympathetic and parasympathetic nervous systems play a major role. Whether it is the act of sex itself, the arousal and alertness prior to sex, or the relaxation period after orgasm, the autonomic nervous system creates all of the physiological changes. In terms of the brain, the sympathetic nervous system creates focus and alertness to impress a potential mate that an individual finds attractive (Aron, 2005). The motivation to bring the parasympathetic response and the reduction of stress-producing steroids is important in promoting well-being and romantic love. Therefore, an individual is attractive if they can provide better security and a reduced sense of anxiety for a mate.

Major Histocompatibility Complex (MHC), Smell, and Evolution

The major histocompatibility complex, MHC, is an important part of the immune system. Therefore, evolution has regulated its genes through sexual reproduction and recombination of genes. Our sense of smell, olfaction, is the oldest of the senses evolving over millions of years. Even though plants and animals that are more primitive only have an innate immune system, they had certain molecules that produced and maintained a chemical identity. These molecules had a scent or chemical signature to them, and modern day perfumes take advantage of this fact. The theory is that certain fragrances accentuate our personal MHC proteins through what we know as pheromones. These chemicals are secreted in heavy amounts from apocrine sweat glands that are concentrated in areas such as under the arms, face, and genital region. The MHC proteins allow our immune system to detect, present, and destroy infectious agents. Having certain MHC proteins will provide resistance, and therefore survival, to infectious agents that control reproductive success. In certain species that can reproduce asexually and sexually, populations that have no contact with parasites do not have sexual reproduction, while populations under stress by infection have widespread sexual reproduction. In other words, sex provides the recombination of important genes in evolution. Just as scent can detect an infection, odors can be used to detect a healthy individual with complementary MHC proteins. Those healthy individuals will be attractive to another healthy individual with different MHC proteins. In essence, the paired individuals will produce offspring with optimal combined immune response (Milinksi, 2006).

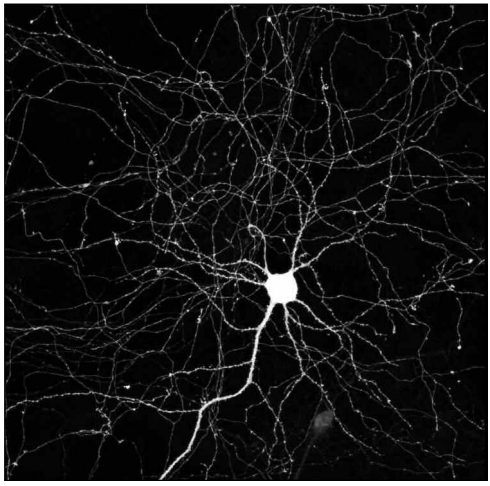
MHC and Immune Interactions



Nerve Growth Factor

Nerve Growth Factor, NGF, is highly expressed in early stages of love, while other neurotrophins are not. It produces and maintains connections between neurons. Induced stress does not cause expression of NGF alone. Therefore, it seems to play some role in early romantic love by mediating anxiety, emotion, and behavior. Levels of NGF return to basal levels roughly a year after the beginning of a romantic relationship. Since NGF induces production and release of vasopressin, it regulates a role in social bonding (Emanuele, 2005). NGF may be the secret to the checkpoint between short-term attraction and long-term love.

Neuron expressing NGF



Attachment

Common only in monogamous or highly social animals with long periods of child development, attachment is the close bonding that occurs between a couple or a mother and child. While the two are distinct, they may share the same neurobiology of reward and evolutionary basis to promote bond formation. In addition, the bonding between two individuals provides a certain connection that reduces stress, improves overall health, and provides an important coping mechanism through companionship (Esch, 2005). The system of attachment between two individuals in

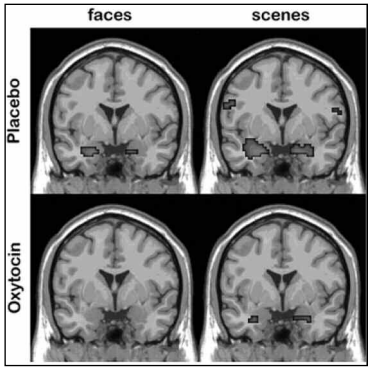
'Til Death Do Us Part

romantic love involves defense of territory, feeding and grooming, close proximity, separation anxiety, and shared tasks. These factors lead to emotional calm, comfort, and union (Fisher, 2002). The bonding of the couple provides the necessary cooperation to provide the best care possible for future generations, despite perceived differences.

Oxytocin and ADH

Neurobiologically, the peptides oxytocin and vasopressin seem to play the largest role in close bonding. The hypothalamus produces both oxytocin and vasopressin, and the hypothalamus is important for regulating many different endocrine pathways. Stress hormones from the adrenal glands play a role in regulation of the hypothalamus hormones and vice versa. Oxytocin modulates social behaviors such as maternal aggression and care, bonding, sexual behavior, memory, social support, trust, and reduction in stress (Neumann, 2007). Oxytocin, specifically, inhibits the release of stress hormones from the adrenal cortex, causes uterine contraction and orgasm, causes milk ejection, promotes overall relaxation, and reduces immune suppression. Stress versus relaxation between corticosteroids and oxytocin creates the struggles that strengthen bonds, trust, and devotion between individuals. Therefore, love is a double-edged sword that causes temporary stress in the short term and lower stress levels in the long term. Endorphins, which are the brain's natural morphine, are important products of close relationships and provide a reduction in pain, a sense of well being, and a sense of security (Esch, 2005).

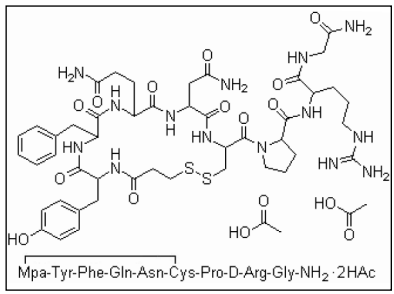
Oxytocin Reduces Fear



Vasopressin, or ADH, is a multifunctional hormone that acts to reabsorb water from the kidneys, regulating the rhythm

of the normal day to night sleep cycle, promoting territorial protection, and strengthening social bonds. In line with the complex interactions of neurotransmitters and hormones, testosterone enhances the action of vasopressin in the brain and increases aggression.

Vasopressin Structure

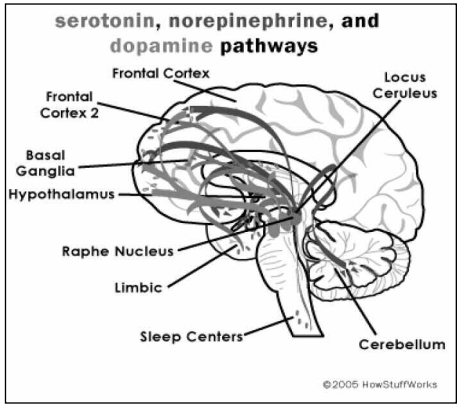


Although the interpretation of vasopressin's action on attachment is somewhat of an assumption, the fact is that vasopressin generates aggression in injected animals. The close interactions of various hormones and neurotransmitters play a role in the long-term maintenance of romantic attachment and bonds between couples. These bonds promote stress reduction, companionship, and an environment where offspring can develop and mature with proper resources and parenting (Esch, 2005).

Conclusion

Romantic love, one of the most rewarding of all human endeavors, comprises the three stages of lust, attraction, and attachment. The brain activities of the three stages are very different and distinct, but have certain similarities. Lust provides the drive and desire for sex, attraction allows for a choice in the most suitable mate, and attachment provides the means for a couple to stay together for enough

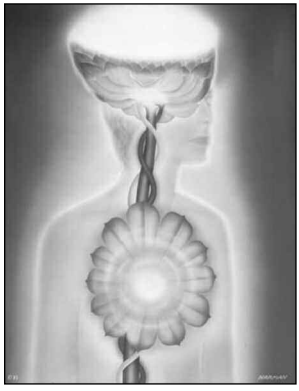
Neurotransmitter Web of Activity



time to provide for offspring. Many neurotransmitters and hormones such as testosterone and other sex steroids, corticosteroids, dopamine, norepinephrine, oxytocin, and vasopressin play a role in romantic love. The independence of the stages may have given an evolutionary advantage to using different reproductive strategies at the same time such as serial monogamy, permanent monogamy, or side mating. Unfortunately, this independence leads to adultery, divorce, jealousy, murder, and depression due to loss of the important bond and relationship (Fisher, 2002).

The relaxation that comes with bonding and having a companion is important in reducing stress and improving overall health and immunity. In fact, the ability to maintain balance, adapt, and cope with stress improves reproductive success and makes an individual more attractive to potential mates (Esch, 2005). In terms of immunity, complementarity in the MHC genes provides the best mixture of defense against infectious agents. Fascinatingly, the MHC proteins provide a certain fragrance, or pheromone, that may be attractive to only individuals with complementary MHCs (Milinksi, 2006).

Even as scientists learn more and more about the brain, fully grasping the emotions and meaning of the phenomenon, romantic love, is impossible without further study. The desire to belong to something and love someone has provided the motivation for some of the greatest art and achievements of humanity throughout time. In few words but not as simple as it sounds, the brain secretes its neurotransmitters and acts on the rest of the body in the rush of love. Jules Renard once said, "Love is like an hourglass, with the heart filling up as the brain empties."



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