NEUROANATOMY OF INTIMACY

1 Even though intimacy has been broadly defined in terms of romantic love and sexual desire, the **neuroanatomy of intimacy** needs further explanation in order to fully understand their neurological functions in different components within intimate relationships, which are romantic love, lust, attachment, and rejection in love. Also, known functions of the neuroanatomy involved can be applied to observations seen in people who are experiencing any of the stages in intimacy. Research analysis of these systems provide insight on the biological basis of intimacy, but the neurological aspect must be considered as well in areas that require special attention to mitigate issues in intimacy, such as violence against a beloved partner or problems with social bonding.

COMPONENTS OF INTIMACY AND NEUROANATOMY

Attachment

2 Pair bonding, or intense social attachment, normally initiates partner preference in sexual situations and monogamy in many mammalian species. Monogamous species generally exhibit an exclusive responsibility to each other as well as co-parenting to their offspring. Studies using monogamous prairie voles (*Microtus ochrogaster*) showed that forming a pair bond stimulated the mesolimbic dopaminergic pathway. In this pathway, dopamine is released from the ventral tegmental area (VTA) to the nucleus accumbens and prefrontal cortex, which then signals the ventral pallidum to complete reward processing in the pathway.

3 Two important neuropeptides that mediated pair bond formation were oxytocin and arginine vasopressin (AVP). Even though both males and females have both molecules, oxytocin was shown to be predominantly in females and vasopressin predominantly promoted pair bonding in males. Receptor specificity was shown essential for mating by activating the dopamine D2 receptors in the nucleus accumbens in male and female prairie voles. Other locations that were also activated in the study were gender specific on the other hand, such as oxytocin receptors (OTR) in the prefrontal cortex and arginine vasopressin-1a receptors in the ventral pallidum.

Romantic Love

4 Romantic love is described as involving an individual who pays closer attention to another individual in special ways, involving attention on traits worthy to pursue. Through functional magnetic resonance imaging (fMRI), studies have shown that the right ventral tegmental area (VTA) is stimulated when subjects are shown a picture of their beloved. As part of the reward mechanism, the VTA signals to other parts of the brain, such as the caudate nucleus to release dopamine for reward.

5 Older studies have generally attributed love to the limbic system consisting of the temporal lobes, hypothalamus, amygdala as well as the hippocampus. These functional components of the limbic system are important components of emotional processing, motivation, and memory. Specifically, current research also suggests components, such as the hypothalamus, as playing a role in romantic love because it possesses the penchant for bonding in mammals by secreting the neuropeptides, oxytocin and vasopressin. Other research has implicated nerve growth factor, a neurotrophin that is fundamental in the neuron survival and development in the nervous system, in early-stage romantic love in subjects experiencing euphoria and emotional dependency, which is often a characteristic in romantic love.

Lust

6 Lust, also known as libido, is defined as pursuing sexual gratification. It is primarily driven by the endocrine system, but the brain is also involved in neural processing. Specifically, the hypothalamic-pituitary-gonadal (HPG) and hypothalamic-pituitary-adrenal (HPA) axes play primary roles in the priming for sex as well as the stress response, respectively. Because intimacy is motivated by the reward system, steroid hormones activate desire to promote partner preference and social attachment in the process of sexual union. Dopamine is then released when an individual is aroused, which associates lust as a product of the dopaminergic reward system. However, interactions of sex and romantic love do not have the same goal orientation, which helps to confirm the difference in brain activation patterns. Contrasting with the primary goal of romantic love, copulation can occur without two individuals having a monogamous bond. Sometimes, copulation might not even occur in romantic love relationships.

Rejection in Love

7 Rejection in love is considered unrequited or unreciprocated love. Separation from a loved one can cause grief and sometimes lead to an individual expressing characteristics of depression. In a study, symptoms seen in nine women who had experienced a recent breakup suggested involvement of certain neuroanatomy. Eating, sleeping, and neuroendocrine regulation was associated with the hypothalamus, anhedonia was associated with the ventral striatum and the amygdala was associated with emotional processing in these women. Other neuroanatomy that registered unrequited love included the cerebellum, insular cortex, anterior cingulate cortex, and prefrontal cortex. All of the areas that were activated showed decreased activity when subjects emotionally reflected about the beloved rejecter.

8 In contrast, another study observed significant increase in activation in the VTA as well as the nucleus accumbens. Further, those rejected in love had higher stimulation in the right nucleus accumbens and ventral putamen/pallidum compared to subjects who were in romantic in love. This study ultimately showed that areas that are activated in romantic love are also activated in rejection in love. Results from this study suggest that rejected lovers have same stimulation of brain regions because they are still "in love" with their rejecters. Since romantic love follows the dopaminergic reward system, the anticipatory nature of receiving a reward as well as deciding on losses and gains in decision making, allows the neural circuitry to become adaptable. This allows the rejected to change their behavior through two stages. The first is the "protest" stage where they try to win back the rejecter. The second stage or the "rejection" stage is where they feel resignation and despair, eventually leading to continuing life without the rejecter. On the other hand, the involvement of the reward gain/loss pathways intrinsic to survival provides insight on behaviors of stalking, suicide, obsessiveness and depression.

OTHER NEUROLOGICAL IMPLICATIONS OF INTIMATE BRAIN SYSTEMS

Mother-child pair bond

9 Attachment between a mother and a child is an evolutionary mechanism for a mother to care for and protect her children. This attachment stems from behavioral changes during birth, which includes lactation. Release of oxytocin is important in the birthing process for the mother-child pair bond to occur in both individuals. Lactation relies on the constant release of oxytocin for the release of milk in the breast, which strengthens the first social bond of the infant and the mother.

10 Although this is considered another type of social attachment that activates the same reward system, maternal attachment activates different regions of the brain compared to those in partner attachment. In one study, overlap of activated brain regions with romantic love was found to include the nucleus accumbens, putamen, caudate nucleus, which are important in social attachment. However, the only regions that were specific to maternal love were the

orbitofrontal and lateral prefrontal cortex as well as the occipital and lateral fusiform cortex. Moreover, oxytocin is important between the mother and her offspring, so it is suggested that oxytocin deficiency can influence how successfully the offspring is able to form a monogamous pair bond with another individual in the future. This may provide insight on issues with formation of pair bonds as well as psychological problems from an inefficient upbringing.

Is love addictive: Myth or Fact?

11 Love activates the same neural circuitry as maladaptive drugs, such as cocaine. Dopaminergic reward pathways are involved to elicit a response of gaining a reward and reinforcement, thereby leading some researchers to believe that love is addictive. Love and drugs of abuse simulate similar levels of dopamine for reward and reinforcement from the VTA. Actions between the two mental states are very similar with those in love experiencing excessive exhilaration, insomnia, anxiety, and loss of appetite also seen in drug users. Also, brain activity observed through single-photon emission computed tomography (SPECT) showed that dopamine release in the basal ganglia of a subject who was romantically in love appeared similar to a subject addicted to cocaine. Although love is suggested to be addictive based on its neurological circuitry, it cannot be simplified as addictive because it is expressed in different ways across a wide spectrum.

BIOLOGICAL BASIS OF LOVE

12 The theory of a biological basis of love has been explored by such biological sciences as evolutionary psychology, evolutionary biology, anthropology and neuroscience. Specific chemical substances such as oxytocin are studied in the context of their roles in producing human experiences and behaviors that are associated with love.

Evolutionary psychology

13 Evolutionary psychology has proposed several explanations for love. Human infants and children are for a very long time dependent on parental help. Love has therefore been seen as a mechanism to promote mutual parental support of children for an extended time period. Another is that sexually transmitted diseases (STD) may cause, among other effects, permanently reduced fertility, injury to the fetus, and increase risks during childbirth. This would favor exclusive long-term relationships reducing the risk of contracting an STD.

14 From the perspective of evolutionary psychology the experiences and behaviors associated with love can be investigated in terms of how they have been shaped by human evolution. For example, it has been suggested that human language has been selected during evolution as a type of "mating signal" that allows potential mates to judge reproductive fitness. Miller described evolutionary psychology as a starting place for further research: "Cognitive neuroscience could try to localize courtship adaptations in the brain. Most importantly, we need much better observations concerning real-life human courtship, including the measurable aspects of courtship that influence mate choice, the reproductive (or at least sexual) consequences of individual variation in those aspects, and the social-cognitive and emotional mechanisms of falling in love." Since Darwin's time there have been similar speculations about the evolution of human interest in music also as a potential signaling system for attracting and judging the fitness of potential mates. It has been suggested that the human capacity to experience love has been evolved as a signal to potential mates that the partner will be a good

parent and be likely to help pass genes to future generations. Biologist Jeremy Griffith defines love as 'unconditional selflessness', suggesting utterly cooperative instincts developed in modern humans' ancestor, Australopithecus. Studies of bonobos (a great ape previously referred to as a pygmy chimpanzee) are frequently cited in support of a cooperative past in humans.

Role of the limbic system

15 In a General Theory of Love, three professors of psychiatry from UCSF provide an overview of the scientific theories and findings relating to the role of the limbic system in love, attachment and social bonding. They advance the hypothesis that our nervous systems are not self-contained, but rather demonstrably attuned to those around us and those with whom we are most close. This empathy, which they call limbic resonance, is a capacity which we share, along with the anatomical characteristics of the limbic areas of the brain, with all other mammals. Their work builds on previous studies of the importance of physical contact and affection in social and cognitive development, such as the experiments conducted by Harry Harlow on rhesus monkeys, which first established the biological consequences of isolation.

Brain imaging

16 Brain scanning techniques such as Functional magnetic resonance imaging have been used to investigate brain regions that seem to be involved in producing the human experience of love. In 2000, a study led by Semir Zeki and Andreas Bartels of University College London concluded that at least two areas of the brain become more active when in love. These were foci in the media insula, which the brain associates with instinct, and part of the anterior cingulate cortex, which is associated with feelings of euphoria. Ortigue et al. found that an unconscious prime of the name of a romantic partner activated similar brain regions as when subjects were consciously aware of seeing partners' faces. Subliminal priming with either a beloved's name or a favorite hobby activated emotion and motivational brain regions: caudate nucleus, insula, bilateral fusiform regions, parahippocampal gyrus, right angular gyrus, occipital cortex, and cerebellum. However, the love prime evoked more activation in bilateral angular gyri and bilateral fusiform regions than the hobby prime. These regions are associated with integrating abstract representations, and the angular gyrus in particular is involved with abstract representations of the self. The authors also found a correlation ($r=0.496$, $p=0.002$) between activation of a region of the angular gyrus with a passionate-love scale measuring subjective feelings of love

QUESTIONS

1- A) According to the information given in the passage, which of the following is certainly true about neuropeptides?
   a) Their function in the brain is restricted to pair bonding
   b) They are molecules
   c) They are active in females, but not in males
   d) There are no more than two neuropeptides

B) Which one(s) of the following regions are activated in either males or females, but not both, during pair bonding? Put a ✓ in the space provided.
   1- Dopamine D2 receptors [_____]
   2- Oxytocin receptors [_____]
   3- Arginine vasopressin-1a receptors [_____]

2- In addition to its function in romantic love, in what other area does nerve growth factor serve a central function?
   ……..

3- Lust and romantic love are associated with different aims, and produce different activities in the brain.
a) What is the main aim of lust?
   ……...
b) What is the main aim of romantic love?
   ……

4- The passage implies that the undesirable and tragic consequences occurring in cases when the rejected cannot change their behavior through 'protest' and 'rejection' can be explained by
   ……

5- The consequent psychological problems when one is not provided for adequately by his mother as he grows up, and the inability to form pair bonds may be traced back to
   …….....

6- What symptoms do a person in love and a drug addict share?
   ……

7- The passage lists three means (suggested by evolutionary psychologists) by which humans have demonstrated their "fitness" to potential mates. What are those?
   1- …….
   2- ……....
   3- ……

8- What is the name given in the passage to the accommodation of human nervous system to the people in the immediate environment?
   ……..

9- In a *brain imaging experiment* the experimenter has a woman smell her partner's perfume to see whether the perfume itself will activate the same regions in the brain as those activated when the woman sees her partner. What method is the experimenter using?

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