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NEUROBIOLOGY OF LOVE

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SUMMARY

Romantic love is a "universal… or near universal" human phenomenon. Recently, love, romantic love, also became a theme of interest for scientists. The current research is seeking an explanation to clarify the brain mechanisms that are responsible for love behavior and feelings. Until recently, the study of love has been mainly the field of psychology. The biology of love originates in the primitive parts of brain that eolved long before the cerebral cortex. Discoveries in neuroscience have led to the identification of specific areas, facilities, brain circuits that are involved in the genesis of love. However, love remained a research field mainly for psychologists, despite the massive increase in neuroscientific research. In the last few decades, there has been a significant increase in the number of studies on the neuronal corelates of love, through the use of neuroimaging techniques (fMRI, PET) and in the studies that have investigated the action of the neurotransmitter and neuroendocrine systems.

Key words: *love – neurobiology – neuroimaging - mate choice*

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INTRODUCTION

Romantic love is a "universal…or near universal" human phenomenon. *"Animals – including humans – spend an inordinate amount of time getting ready to have sex. Something that could be achieved by mutual agreement in a misure or two is commonly draw out into hours, days, even weeks of assiduous pursuit, comical misadventure, and brain-numbing stress. In a word: '' courtship"* (LeVay 1994)… and love.

Love has been a focus of attention since the beginning of mankind, and it has been an important topic for artists. Recently, love, romantic love, also has become a theme of interest for scientists (de Boer et al. 2012). Research is currently seeking an explanation to clarify the brain mechanisms that are responsible for love behaviour and feelings. Until recently, the study of love has been mainly the field of psychology.

From an evolutionary perspective, matters of significance relate primarily to activities assocaited with acquisition and retention of emotions needed to survive and reproduce. So these emotions change the individual's behavioral strategies in a way that will increase the likehood of achieving these goals (Gear 2005). But do these evolutionarily determined behaviours have a biological substrate and a correlation with the activation of specific brain areas? Fisher (Fisher et al. 2002) hypothesized that a mate choice is associated with a neural network evolved to enable "display chooser" to focus their mating energy on specific potential mating partners, thereby conserving courtship time and metabolic energy.

Discoveries in neuroscience have led to the identification of specific areas, facilities, brain circuits that are involved in the genesis of love. However, love remained a research field mainly for psychologists, despite the massive increase in neuroscientific research. Love is an emotion which can be explained by studying brain activity and understanding neuronal correlates of loves. Searching the neurobiology of love, "neurobiologists of the future will also be looking into evidence derived from the world literature of love, since literature is itself a product of the brain and its careful study gives strong hints about how the romantic system in the brain is organized" (Zeki 2007).

Thus in the last few decades, there has been a significant increase in the number of studies of the neuronal corelates of love, through the use of neuroimaging techniques (fMRI, PET) and in the studies that have investigated the action of the neurotransmitter and neuroendocrine system.

BRIEF OUTLINE OF ENDOCRINE FACTORS IN LOVE

Like any other emotion, love is regulated by endocrine factors. Several factors have been identified as playing a role in romantic love and attachment, including oxytocin, vasopressin, dopamine, serotonin, cortisol and other hormones, nerve growth factor, and testosterone. The domapine reward system interacts with other hormones (e.g., oxytocin and vasopressin), making love a rewarding experience. The neuropeptides oxytocin and vasopressin contribute to the processing of social cues necessary for individual recognition. Mesolimbic dopamine is involved in reinforcement and reward learning. Concurrent activation of neuropeptide and dopamine receptors in the reward centers of the brain during mating results in a conditioned partner preference, observed as a pair bond (Lieberwirth & Wang 2014). Areas mainly involved in the relationship individual recognition/rewarding experience are the

nucleus accumbens, the ventral tegmental area, the paraventricular hypothalamic nucleus, and the prefrontal cortex. As emphasized in a review, reward and motivation related dopaminergic areas are an essential component of the social brain network (SBN). Dopaminergic areas are highly engaged during male courtship of females (O'Connell & Hofmann 2011). The research team of Iwasaki (Iwasahi et al. 2014) suggested that in the reward areas the inhibition of fear or avoidance networks may be associated with development of close affiliation, and highlights the importance of negative as well as positive emotional states in the process of courtship, and in development of long-lasting social bonds.

Aragona hypothesed that upregulation prevents the formation of new pair-boinds and thereby maintains stability of the existing bond (Aragona et al. 2003). The authors first demonstrated that dopamine is necessary for the formation of social attachment in male prairie voles, because administration of haloperidol blocked, whereas apomorphine induced, partner-preference formation.

Another substance implicated in love and pair-bonding is the neurotrasmitter serotonin.A depletion of central levels of serotonin was found in the early stages of romantic love; as happens in OCD, depression, and anxiety disorder. Indeed, ealy stages of romantic love show similarities to these disorders (e.g. symptoms of anxiety, stress and obtrusive thinking) (de Boer et al. 2012).

Among neuroendocrine factors, oxytocin and vasopressin play an important role in pair-bonding and love. The evolutionarily conserved neuropeptide oxytocin is associated with the formation of partner bonds in some species via interactions with brain dopamine reward systems. One element that repeatedly features in the biochemistry of love is the neuropeptide oxytocin. This peptide is released in response to acutely stressful experiences; and it is involved in the care for infants, and also in stabilizing a loving relationship and ensure that we will seek and receive support from others. Recent data suggest that oxytocin could contribute to romantic bonds in men by enhancing their partner's attractiveness and reward value compared with other women (Scheele et al. 2013); while in women selectively oxytocin promotes approach behavior in positive social contexts (Preckel et al. 2014).

Vasopressin is associated with physical and emotional mobilization, and supports vigilance needed for guarding a partner or territory. Vasopressin, together oxytocin, are released into the brain, facilitating preference for a mating partner and thus instituting pair-bonding (de Boer et al. 2012).

However, there are differences between the two neuropeptides in their effects. Oxytocin has anxiolytic and stress-reducing effects, vsopressin increases fear and stress response. This is due probably to opposite effects on amygdala.

BRIEF OUTLINE OF NEUROIMAGING STUDY IN LOVE

Neuroimaging studies have mainly focused on the cortex, the medial insula, anterior cingulate, and hippocampus and, in the subcortex, parts of the striatum and nucleus accumbens; all of these regions are core regions of the reward system (Guo et al. 2013). The areas actived in response to romantic feelings are those that are associated with reward, desire, addiction and euphoric states, namely dopamine (Weiland et al. 2014).

In an investigation (Fisher et al. 2010), functional magnetic resonance imaging(fMRI) was used to study happiness in love and thus it has been possible to identify group regional activations related to a naturally occurring, emotionally chaotic, motivational state that may have value for survival and reproduction, namely to win back a mate. The authors concluded that activation in the ventral tegmental area, nucleus accumbens, and an extended forebrain gain/loss system in this group of individuals was adaptive or maladaptive for them, but that it indicates the motivational relevance of the rejecter.

Another recent question is how romantic expressions – especially when unexpected – can lead us to update our beliefs about another person’s thoughts and motivations. In a recent fMRI study the group of Cooper has identified that expressions of interest and rejection activated regions previously associated with “mentalizing,” including the posterior superior temporal sulcus (pSTS) and rostromedial prefrontal cortex (RMPFC); while pSTS responded to differences from the participant's own decision, RMPFC responded to prediction errors from a reinforcement-learning model of personal desirability. Responses in affective regions were also highly sensitive to the participants' expectations. RMPFC p and STS are thought to support incorporating new social information into beliefs about others (Cooper et al. 2014).

Another recent area of research has focused on the brain network of intense love; to examine the neural correlates of long-term romantic love. Acevedo and colleagues (Acevedo et al. 2012) investigated the neural correlates of long-term romantic love and attachment by applying fMRI to a group of long-term happily married, sexually monogamous individuals reporting intense romantic love for their partner. In this study, participants were shown facial images of their partner and a highly familiar acquaintance permitting a direct, controlled comparison of results between the partner and the acquaintance. Individuals reporting intense, long-term romantic love showed neural activity in response to images of their partners (vs various controls) in mesolimbic, dopamine-rich regions important for reward-processing and motivation. Specifically, early-stage and long-term romantic love commonly recruited the right ventral tegmental area and caudate, even after controlling for close friendship and familiarity.

A recent this fMRI meta-analysis review (Juan et al. 2013) reveladed a shared brain network between intention understanding and passionate love that includes brain regions sustaining social cognition, embodies cognition, mentalizing about self-other, bilateral superior temporal sulcus, bilateral inferior frontal cortex, ventromedial prefrontal cortex, anterior insula as well as brain regions involved in the mesolimbic and nigrostriatal dopaminergic pathways (caudate nucleus, thalamus, putamen, and parahippocampal area).

CONCLUSION

Evidence from human fMRI and neurobiological studies support the hypothesis that multiple reward regions using dopamine are activated during feeling of romantic love; and also provides strong evidence for a link between a specific brain region and a specific brain function, romantic love.

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