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The neuropsychology of love: Mechanisms of love in the human brain

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ABSTRACT

Love is one of the most powerful positive emotions experienced by human beings. When caught up in love, individuals undergo neurochemical changes in brain regions such as the amygdala, hippocampus, and prefrontal cortex. These changes are triggered by increased blood flow, reflecting the complex interplay between love and brain activity. Accordingly, this study aims to explore how love influences brain function, the various types of love, and their respective impacts on individuals. This will be explored through a literature review of previous studies on the types and characteristics of love, as well as the neural and hormonal activity associated with it. This study employed a systematic literature review approach, resulting in fifteen selected articles for synthesis. The findings indicate that types of love include romantic love, maternal love, filial love, unconditional love, and friendship. Moreover, the hormones involved in love include oxytocin, dopamine, and testosterone. The study also reveals that visual processing of a loved one's face engages complex brain mechanisms. Unique characteristics of love include sexual desire, emotional conflict, and attachment.

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Introduction

Love is a universal phenomenon. Everyone experiences love in life, either as someone who loves or is loved (Kokab & Ajmal, 2012). Although love may not traditionally be considered a scientific concept, it has attracted considerable attention from researchers and scholars, particularly in the field of psychology. Just as humans require food, water, sleep, and other basic needs, love is also essential for survival (Maslow, 1943; Maslow, 2007). This is because love constitutes a fundamental aspect of self-actualization, which involves personal growth and the pursuit of happiness (Ventegodt et al., 2003).

Multiple studies have demonstrated that love influences various aspects of human life. According to Rorty (2016), love can affect an individual's priorities, such as how they allocate time and attention. Furthermore, love helps shape identity, purpose, happiness, and even the burdens one carries (Rorty, 2016). In this context, Walum and Young (2018) described love as one of the most powerful human emotions. The emotional experiences generated by love have also been shown to serve as protective factors against existential anxiety and to enhance individual well-being and quality of life (Gawda & Korniluk, 2023). Moreover, human emotions are not merely physiological responses but also involve neural activation processes (Sachs et al., 2018).

The biological, neurological, and endocrine aspects of love have become increasingly prominent in scientific investigations. From a neuroscientific perspective, love is regarded as more than a basic emotion or mental state (Tarlacı, 2012). It engages multiple interconnected brain regions that function as a complex system, particularly areas associated with emotion, reward, motivation, and cognitive regulation. The initial brain system activated when a person experiences love is the brain's reward system, located in the midbrain (Xu et al., 2011; Fisher et al., 2016). Additionally, when individuals experience love or speak about loved ones, regions such as the amygdala, hippocampus, and prefrontal cortex become active during neuroimaging due to increased blood flow in these areas (Cacioppo, 2022). Activation in these regions gives rise to a range of physical and emotional responses, such as a racing heart, sweaty palms, flushed cheeks, arousal, and anxiety (Puranik et al., 2020).

Numerous studies have shown that being in love is associated with increased happiness. This is supported by a study conducted by Aron et al. (2005), which found that when individuals view photographs of their loved ones, brain regions rich in dopamine, commonly known as the "feel-good" neurotransmitter, are activated. This activation elicits various positive emotions such as pleasure, satisfaction, and a sense of reward (Aron et al., 2005). In addition, serotonin plays a critical role in regulating mood, promoting relaxation and calmness, and enhancing feelings of happiness in romantic relationships (Stein & Vythilingum, 2009). These findings suggest that love has the capacity to generate a range of positive emotional experiences in individuals.

However, love may also have adverse effects, one of which is love addiction (Reynaud et al., 2010). Love addiction refers to an excessive attachment to a partner and an inability to disengage from the relationship, even when it becomes detrimental (Guan, 2024). This form of addiction is comparable to the psychopathology associated with substance use disorders. Neuroimaging studies reveal that the neural activations involved in both substance addiction and love may follow similar neurobiological pathways, both associated with feelings of euphoria and impulsive urges (Uddin, 2017). These mechanisms help explain why love often produces intense emotions and, at times, obsessive behaviors. Moreover, love addiction can negatively affect various domains of functioning, including emotional regulation, the quality of social relationships, and work productivity (Gori et al., 2023). In more severe cases, love addiction may result in mental health disturbances and reduced overall well-being.

Over time, the development of literature on love has been widely explored in social psychology research. Social neuroscientists have begun to contribute to a more nuanced understanding of passionate love by mapping its specific neural circuits in the human brain (Ortigue et al., 2010). Uddin (2017) further explored the biochemical and biological processes associated with love and the human potential for developing love addiction. Additionally, Puranik et al. (2020) examined the metamorphosis of love across various life stages, the neural circuits underlying affection, and the myths surrounding the notion of "eternal love" in the human brain. A meta-analysis conducted by Shih et al. (2022) highlighted differences in the functional convergence of two major forms of human love, maternal love and romantic love, based on neuroimaging results. Nevertheless, neurological studies on love remain relatively limited. Existing studies are often limited by small sample sizes, an overemphasis on the early stages of romantic relationships, and methodological challenges in isolating the complex emotional and motivational components of love itself (Aron et al., 2005; Cacioppo et al., 2012). Despite recent advances in cognitive and affective neuroscience, advances that have enabled psychologists and neuroscientists to examine the processes underlying romantic love, including its motivational basis, these challenges persist (Yovell, 2008).

In light of the foregoing, the present study seeks to explore the brain mechanisms of love in a more comprehensive and systematic manner, thereby offering a more holistic understanding than prior research. The primary objective of this study is to conduct a literature review of previous research addressing the types and characteristics of love, as well as the neural and hormonal activity associated with it. This study adopts an integrative

approach, synthesizing findings from psychology and neuroscience to conceptualize love as a complex phenomenon within brain activity. The novelty of this study lies in its focused examination of different types of love, along with the associated brain activity and hormonal involvement.

Method

This article was written using a literature review method, which involves examining various existing studies and synthesizing them into a comprehensive narrative (Dudovskiy, 2022). In academic contexts, literature reviews are considered scholarly work because data collection is conducted through a structured methodological strategy, as is common in empirical research (Melfianora & Si, 2019). The literature review process typically begins after the researcher has selected a specific topic to explore prior to data collection (Darmadi & Azwar, 2011). The data sources for literature reviews can include a variety of materials such as textbooks, journal articles, and other relevant publications, as long as they are related to the concept under investigation (Kartiningrum, 2015).

This study was conducted by systematically collecting research articles accessed through three databases: ScienceDirect, Scopus, and ProQuest. The keywords used for article searches in ScienceDirect and Scopus were: ("neuropsychology" OR "neuroscience") AND "love". For the ProQuest database, the following keywords were used: ("neuropsychology" OR "neuroscience") AND ("passionate love" OR "companionate love" OR "maternal love" OR "unconditional love"). The keywords for ProQuest were constructed with greater specificity to narrow down the search results and ensure greater relevance to the research topic, given the database's extensive and multidisciplinary collection of literature. The inclusion criteria for selecting articles were as follows: (1) the article discusses the neuropsychology of love; (2) the study participants are human; (3) the article is written in English; (4) the study is empirical, either quantitative or qualitative; and (5) the article is available for download in full-text format.

The researcher conducted searches in the three databases and initially identified 101 publications related to the topic of the neuropsychology of love. In the initial screening phase, three duplicate articles were removed, and 62 articles were excluded based on their titles and abstracts. A total of 36 articles with relevant titles and abstracts were selected for full-text review. Following a detailed reading, 21 articles were excluded for the following reasons: the study background did not address human neuropsychological conditions in the context of love (background article), the study involved non-human participants (wrong population), the article was published as a book (wrong publication type), the research design was non-empirical (wrong study design), or the full text was not accessible (could not locate full-text). As a result, 15 articles were included in the final analysis. The entire article selection process is illustrated in a PRISMA diagram (Figure 1).

Of the 15 articles included, 12 were experimental studies, one was a non-experimental quantitative study, and two were empirical literature reviews. The oldest study was published twenty years ago (Bartels & Zeki, 2004), while the most recent study was published in 2023 (Blumenthal & Young, 2023).

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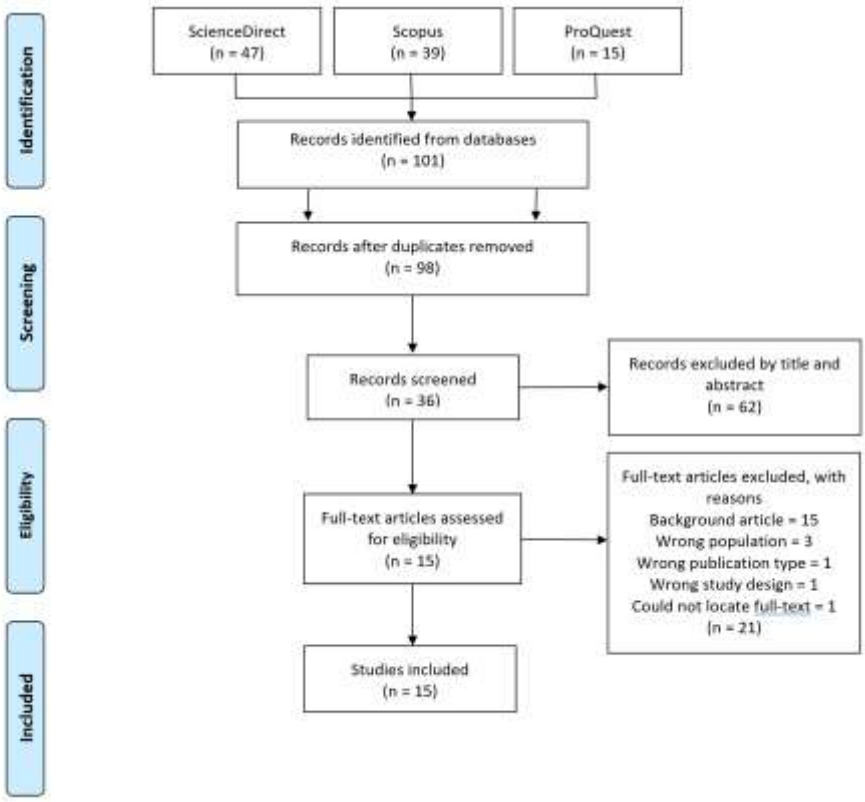

Figure 1. PRISMA Diagram

Results

The synthesis of the fifteen selected articles revealed four key themes: (1) types of love and brain activation, (2) hormonal processes in love, (3) brain activity in response to the face of a loved one, and (4) the unique characteristics of love. A complete list of the selected articles is presented in Table 1.

Table 1. List of Articles

No.	Authors/Year	Title	Method	Findings
1	Blumenthal & Young (2023)	*The Neurobiology of Love and Pair Bonding from Human and Animal Perspectives*	*Experimental*	Love does not emerge at first sight, but is formed through the accumulation of information that creates a deep emotional bond, mediated by oxytocin, which also sustains long-term attachment in both romantic and parent-child relationships. Sexual desire activates brain regions such as the amygdala, nucleus accumbens, and prefrontal cortex, which are also engaged when a person is in love.
2	Shih, et al. (2022)	*The Neurobiological Basis of Love: A Meta-Analysis of Human Functional Neuroimaging Studies of Maternal and Passionate Love*	Empirical Literature Review	Maternal love predominantly involves brain regions such as the left putamen, left substantia nigra, right thalamus, left ventral tegmental area (VTA), and amygdala—associated with emotional and cognitive regulation. Bilateral VTA activation, which reflects a combination of liking and wanting, was observed in romantic love.

No.	Authors/Year	Title	Method	Findings
3	Durdiaková, et al. (2017)	How Do We Love? Romantic Love Style in Men Is Related to Lower Testosterone Levels	Quantitative	Higher testosterone levels are considered incompatible with long-term relationships and deep romantic attachment.
4	Takahashi, et al. (2015)	*Imaging the passionate stage of romantic love by dopamine dynamics*	Quantitative	Individuals in love experience a significant increase in dopamine release, particularly when viewing images of their romantic partner, accompanied by increased heart rate and sympathetic nervous system activity as a physiological response to romantic love.
5	Guerra, et al. (2011)	*Filial versus romantic love: Contributions from peripheral and central electrophysiology*	Experimental	Viewing the face of a loved one (father or romantic partner) triggers stronger autonomic, somatic, and central nervous system responses compared to viewing strangers. Filial love also activates brain regions associated with attachment and reward, with higher P3 amplitude when viewing the father's face than the romantic partner's—possibly due to greater explicit memory involvement.
6	Duan, et al. (2022)	*Is the creativity of lovers better? A behavioral and functional near-infrared spectroscopy hyperscanning study*	Experimental	Romantic love enhances cooperation and brain synchrony between partners, providing neurocognitive evidence of how intimate relationships can influence creativity.
7	Yovell (2008)	*Is There a Drive to Love?*	Empirical Literature Review	Romantic love does not stem from a single biological drive but from the interaction of several systems, including the sex drive, attachment system, and seeking system. Oxytocin plays a key role in forming and maintaining relationships and influences social behaviors such as trust, empathy, and intimacy. The lust system also strengthens emotional closeness and relationship stability. Furthermore, imbalances between sexual desire and emotional attachment can create tension in romantic relationships.
8	Bolmont, et al. (2014)	*Love Is in the Gaze: An Eye-Tracking Study of Love and Sexual Desire*	Experimental	Visual patterns differ between love and sexual desire. Sexual desire is often triggered by viewing the body and activates the ventral striatum, while romantic love more frequently activates the dorsal striatum.
9	Rafi, et al. (2020)	*Impact of couple conflict and mediation on how romantic partners are seen: An fMRI study*	Experimental	Mediation effectively enhances conflict resolution and relationship satisfaction. Conversely, interpersonal conflict reduces brain activation in areas associated with love, reward, and positive emotions.
10	Aghedu, et al. (2021)	*Romantic love affects emotional processing of love-unrelated stimuli: An EEG/ERP study using a love induction task*	Experimental	Romantic love significantly influences emotional processing, enhancing positive, arousing emotions. Romantic attachment aids in emotional regulation, increases emotional engagement and partner focus, and diminishes responses to negative emotional stimuli.
11	Bartels & Zeki (2004)	*The neural correlates of maternal and romantic love*	Experimental	Friendly love is not associated with the same neural activations as other types of love and is expressed more through behavior. Both maternal and romantic love activate reward-related brain regions and deactivate areas associated with social judgment and negative

No.	Authors/Year	Title	Method	Findings
				emotions. Attachment in both types of love is mediated by oxytocin and vasopressin, which also affect social memory and learning.
12	Langeslag, et al. (2007)	*Event-related potential responses to love-related facial stimuli*	Experimental	Faces of loved ones elicit stronger brain responses in the Late Positive Potential (LPP), indicating increased attentional focus compared to faces of attractive strangers or friends.
13	Noriuchi, et al. (2008)	*The Functional Neuroanatomy of Maternal Love: Mother's Response to Infant's Attachment Behaviors*	Experimental	Mothers exhibit brain activation when viewing their child, particularly in the left orbitofrontal cortex (associated with happiness), the right orbitofrontal cortex (associated with anxiety), and the left dorsal putamen (associated with maternal intensity). Maternal attachment and love motivate caregiving behavior and emotional responsiveness to children's needs.
14	Beauregard, et al. (2009)	*The neural basis of unconditional love*	Experimental	Unconditional love activates brain regions such as the caudate nucleus, VTA, and anterior cingulate cortex (ACC), and is mediated by maternal love derived from affection and emotional attachment. Romantic attachment involves activation of reward and emotion systems, fostering safety, suppressing negative responses, and supporting healthy social interactions.
15	Başar, et al. (2008)	*Brain oscillations evoked by the face of a loved person*	Experimental	Delta brain wave oscillations significantly increase when viewing the face of a loved one, compared to familiar or unfamiliar faces.

Discussion

Types of Love and Brain Activation in Humans

Romantic Love

Several types of love are activated in the human brain, including romantic love, maternal love, filial love, unconditional love, and friendship love. Yovell (2008) asserts that the neural mechanisms underlying attraction and mate selection have evolved to form a physiological basis commonly referred to as passionate love, obsessive love, or romantic love. This type of love involves three interrelated components: sex drive, attachment, and attraction. Aghedu et al. (2021) further explain that emotional regulation associated with romantic love can influence neural responses not only to threatening stimuli but also to various positive stimuli and pleasurable emotions.

Moreover, Blumenthal and Young (2023) argue that "love at first sight" does not truly exist; rather, what occurs is initial attraction, which is processed through sensory inputs, particularly visual information. Humans tend to evaluate potential partners based on facial cues, a process in which intranasal oxytocin (IN-OT) administration enhances brain activity in areas responsible for visual processing and reward, alongside the amygdala, which plays a role in gauging social interactions. These processes enable individuals to form intimate relationships based on commitment and characterized by feelings of attachment, joy, trust, and comfort, ultimately leading to the experience of "falling in love." Certain brain regions activated in romantic love overlap with those involved in maternal love, including activation of the insular cortex, striatum, and substantia nigra, as well as deactivation of the right medial prefrontal cortex and the amygdala.

A study by Takahashi et al. (2015) on participants who viewed images of their romantic partners revealed an increase in heart rate and sympathetic nervous system activity. Furthermore, there was a significant increase in medial orbitofrontal and medial prefrontal

cortex potentials in participants exposed to images of their romantic partners, indicating the activation of the dopaminergic system (marked by increased release of endogenous dopamine). Similarly, the findings of Guerra et al. (2011) indicated that viewing the face of a loved one, whether a father or a romantic partner, elicited stronger autonomic responses (skin conductance and heart rate), somatic activity (zygomatic muscle response), and central nervous system responses (P3 amplitude and late positive potentials) compared to viewing unfamiliar faces. In addition, Duan et al. (2022) found that romantic partners (lover dyads) exhibited enhanced performance in realistic problem-solving tasks, as well as improved creativity and collaboration, compared to stranger dyads. This was reflected in a significant increase in activity within the frontopolar cortex. Collectively, these findings demonstrate that romantic love actively enhances the functioning of various brain regions along with the associated neurohormonal mechanisms.

Maternal Love

According to Noriuchi et al. (2008), maternal love is a vital form of affection in the mother–child attachment relationship, particularly in relation to the child's development and mental health. When mothers observe their own children, several brain regions become activated, including the left orbitofrontal cortices, the right hemisphere, inferior frontal gyrus, middle temporal gyrus, anterior insula, the right-side hypothalamus, precentral gyrus, posterior cingulate gyrus, putamen, thalamus, and the left hemisphere periaqueductal gray matter. A more recent study by Shih et al. (2022) revealed that maternal love and romantic love engage similar neural networks. Supporting this, Bartels and Zeki (2004) found overlapping brain activations between maternal and romantic love, including the ventral genu (only for romantic love experienced by women), lateral orbitofrontal cortex, lateral prefrontal cortex, globus pallidus, regions near the frontal eye fields, occipital cortex, and lateral fusiform cortex.

Maternal love also activates the posterior-ventral region of the thalamus and areas near the midbrain periaqueductal (central) gray (Zeki, 2004). Activation of this midbrain area also overlaps with the reticular formation, locus coeruleus, and raphe nucleus, which contributes to the release of oxytocin—a hormone involved in maternal behavior. Beauregard et al. (2008) proposed that maternal love is one of the emotional forms that mediate unconditional love. The rewarding nature of unconditional love shares similarities with both maternal and romantic love, fostering the development of emotional bonds between individuals.

Based on these findings, maternal love is a complex form of love due to its significant interconnection with other types. However, it is primarily focused on the attachment formed between mother and child, particularly regarding a mother's nurturing and affectionate care. Moreover, a mother's love for her child can empower her to maintain vigilance and tireless effort in providing protection and caregiving.

Filial Love

Filial love is recognized as the affection a child feels toward their parents. In a study by Guerra et al. (2011), filial love was examined through the responses of child participants toward paternal figures. It is understood to involve two fundamental mechanisms: attachment and caregiving. This form of love is activated through the cooperation between the brain's reward areas (*anterior cingulate* and *striatum*) and the medial prefrontal cortex, which play roles in attachment formation and interpersonal cooperation. Guerra and colleagues found that participants exhibited greater P3 amplitude when viewing images of their fathers compared to images of romantic partners. This may be attributed to the presence of more explicit memories due to the longer time spent with their fathers. The difference between filial and romantic love lies in the levels of familiarity (higher in filial love) and positive emotional responses (higher in romantic love) experienced by participants.

Unconditional love

Unconditional love, also known as *agape* love, is a form of love characterized by emotional sincerity, joy in the well-being of others, and a willingness to care and serve without expecting anything in return (Post, 2003). Post further explains that unconditional love is regarded as one of the highest forms of spiritual expression in humans because it involves continuous and consistent giving to the recipient. According to an fMRI study conducted by Beauregard et al. (2009), unconditional love is associated with increased activity in several brain regions, including the dorsal head of the caudate nucleus, the ventral tegmental area (VTA), the periaqueductal gray matter, and the rostro-dorsal anterior cingulate cortex (ACC). Within the caudate nucleus, specifically the globus pallidus, activation reflects a person's experience of positive emotional states. In the VTA, activation corresponds to the pleasurable feelings generated by unconditional love, relating to the experiential aspects of positive emotion. Additionally, the study indicates that the periaqueductal gray matter of the midbrain may contribute to the formation of unconditional love through oxytocin activity. Activation of the rostro-dorsal ACC in the experiment may reflect self-awareness of unconditional love. This aligns with previous studies that linked this brain region to conscious awareness of interoceptive and exteroceptive emotional signals (Lane et al., 1997, 1998). Furthermore, unconditional love is also mediated by other brain regions that are involved in both romantic and maternal love, such as the middle insula (Beauregard et al., 2009).

The fMRI study thus demonstrates that unconditional love is mediated by neural systems distinct from those of other love types. Nevertheless, some overlapping brain structures are shared with romantic and maternal love, such as the caudate nucleus, globus pallidus, and VTA. This is due to the fact that, like romantic and maternal love, unconditional love facilitates strong emotional bonds between humans.

Friendship love

Research on love and friendship has produced differing views. Unlike other forms of love, friendship does not appear to involve the same brain and neural activations (Bartels & Zeki, 2004). Bartels and Zeki further note that maternal love across the lifespan may influence adult friendships, although not through shared brain activations, but rather through behaviors expressed toward others. However, a contrasting finding was reported by Shih et al. (2022), who showed that the ventral tegmental area (VTA) was positively correlated with the Inclusion of the Other in the Self (IOS) scale, a measure of interpersonal closeness and connectedness, especially for romantic and friendship love. These differing findings highlight a significant discrepancy in our understanding of friendship love. As such, it remains inconclusive whether friendship love follows a similar neural activation pattern to other types of love in the human brain.

Hormones in Love

Oxytocin

Oxytocin, commonly referred to as the "love hormone", plays a pivotal role in strengthening emotional bonds within relationships. Bartels and Zeki (2004) identified oxytocin as a key hormone in both romantic and maternal attachment. Yovell (2008) explained that oxytocin is released in response to various stimuli such as touch and warmth. These interactions modulate neural pathways involved in trust and empathy, thereby enhancing feelings of closeness within relationships. In this context, oxytocin also works in conjunction with dopamine to establish and reinforce caregiving attachments between individuals (Blumenthal & Young, 2023). Furthermore, oxytocin has been shown to promote emotional security, as well as to coordinate social bonding and affectionate behavior (Carter, 2022). Shih et al. (2022) further revealed that although each type of love activates distinct neural networks, all forms of love engage the brain's reward system and areas predominantly influenced by oxytocin and dopamine.

Dopamine

Dopamine is a neurotransmitter that significantly influences an individual's mood. A study by Takahashi et al. (2015), employing Positron Emission Tomography (PET) to observe dopamine system activity, found that dopamine levels were significantly higher when participants viewed images of their romantic partners compared to when they viewed images of friends. More specifically, individuals in love showed higher dopamine levels, as measured by a visual analog scale. The release of dopamine during romantic love occurs across the synaptic clefts of dopaminergic neurons during excitation triggered by viewing a loved partner's image. The study further explained that dopamine release may not be uniquely associated with romantic love, but rather with the pleasurable experience elicited by love in general, of which romantic love is a prominent example.

According to Gadda (2022), dopamine is also linked to reward processing related to social interaction, which reinforces attachment behaviors. Interactions with romantic partners can activate the brain's reward circuitry, subsequently enhancing emotional bonding and relationship satisfaction (Acevedo et al., 2020). The role of dopamine in this process follows a non-linear relationship—more precisely, an inverted U-shaped curve. This suggests that optimal levels of dopamine enhance satisfaction and strengthen bonds, whereas deviations from this optimal range may lead to diminished emotional engagement or difficulties in interpersonal relationships (Hird et al., 2021). In short, it is important to consider not only the presence of dopamine but also the necessity of maintaining it within an optimal range.

Testosterone

Testosterone is known to be associated with various aspects of human life, including social interaction, emotion, sexuality, and behavior. In relation to human sexual behavior, testosterone levels also play a role in romantic relationships. Specifically, testosterone plays a critical role in human reproductive processes and drives male competition and mating behaviors (Archer, 2006). Findings from a study by Durdiakova et al. (2017) revealed that higher testosterone levels are considered incompatible with long-term relationships and deep romantic attachment. Conversely, lower testosterone levels are associated with a tendency to form lasting, intimate, and stable bonds. This aligns with the earlier study by Edelstein et al. (2014), which found that men and women who are committed and engaged in satisfying relationships generally exhibit lower testosterone levels.

Furthermore, Durdiakova and colleagues noted that within marriage, men with higher testosterone levels tend to spend less time with their families and are at greater risk of divorce. Beyond romantic relationships between men and women, testosterone levels have also been examined in the context of unconditional love. Interestingly, testosterone levels in this form of love tend to be negative, indicating an almost complete absence of testosterone in the experience of unconditional love. This is likely due to the positive correlation between testosterone and more aggressive and less prosocial behavior (Alvergne et al., 2010). By contrast, unconditional love—previously described in the preceding section—is characterized by selfless affection, expecting nothing in return.

Brain Activity in Response to the Face of a Loved One

The visual processing of a person's face elicits complex responses in the brain. This assertion is supported by a study conducted by Basar et al. (2008), which demonstrated that the human brain undergoes intricate changes when an individual views another person's face. These changes include the amplitude of oscillatory responses across multiple frequency bands—delta, theta, alpha, beta, gamma—as well as variations in topological coordinates and response timing. Basar et al. (2008) also found that the brain responds differently to faces depending on the emotional connection between the individual and the person being observed. For example, the brain becomes more active when viewing the face of a loved one compared to someone with whom there is only general familiarity.

This finding is supported by Langeslag et al. (2007), who reported that neural responses in the cortex are more strongly activated by faces associated with romantic relationships than by those linked solely to familiarity or physical attractiveness. Furthermore, when an individual views the face of someone they love, there is increased activity in the frontal, central, and parietal regions of the brain, a phenomenon referred to as the Love Positive Potential (LPP) (Langeslag et al., 2007). These findings suggest that love involves a complex set of brain processes, engaging multiple brain regions to process profound emotional experiences.

A subsequent study by Shih et al. (2022) identified three key findings regarding brain responses to the face of a loved one. First, the brain regions significantly activated by maternal love include the left ventral tegmental area (VTA), right thalamus, left substantia nigra, and left putamen. In contrast, romantic love primarily activates the bilateral ventral tegmental area (VTA). Second, both types of love exhibit overlapping activity in the left VTA, indicating a shared and stable neural mechanism underlying these experiences. Finally, maternal love showed stronger activation in the putamen, suggesting a more prominent role in cognitive-emotional regulation and a greater degree of attachment compared to romantic love. Another study also identified emotional responses to the face of a loved one in the anterior cingulate cortex (ACC). Increased ACC activation corresponds to deep emotional processing and plays a crucial role in the formation of emotional and social bonds (Vila et al., 2019). This enhanced ACC activation occurs not only in response to romantic partners but also to loved ones more broadly.

Unique Characteristics of Love

Sexual Desire

Sexual desire is a significant topic in understanding the dynamics of human relationships, particularly in the context of romantic love and sexual behavior. Conceptually, sexual desire is defined as an orientation focused on fulfilling sexual relationships, characterized by increased frequency and intensity of sexual thoughts and fantasies directed toward a specific individual. Interestingly, sexual desire and romantic love may arise independently or concurrently and do not necessarily lead to one another. A study by Bolmont et al. (2014) revealed that 53% of women and 79% of men reported having experienced sexual attraction without feeling love. This distinction is explained by the fact that sexual desire more frequently activates the ventral striatum, a brain region associated with inherently pleasurable experiences such as sex and food. In contrast, romantic love primarily activates the dorsal striatum, which is involved in conditioning processes where stimuli paired with rewards or pleasure are assigned intrinsic value. These findings highlight that the two forms of affection, sexual desire and romantic love, are rooted in different neurological substrates.

Although it does not always lead to romantic love, sexual desire—along with attachment and caregiving is one of the three fundamental mechanisms underlying romantic love. Sexual desire plays a key role in differentiating romantic love from filial love, such as affection toward family members. This mechanism functions to promote species survival and continuity, underscoring the evolutionary significance of sexual desire in human development (Guerra et al., 2011).

Brain activation during sexual responses has been extensively explored in empirical studies. Blumenthal & Young (2023) reported increased activity across multiple brain regions during sexual arousal and orgasm. In men, the areas involved include the amygdala, hippocampus, medial prefrontal cortex (mPFC), nucleus accumbens (NAc), orbitofrontal cortex (OFC), anterior cingulate cortex (ACC), and insular cortex (IC). In women, fMRI studies have shown that during orgasm, there is heightened activity in the prefrontal cortex (PFC), insular cortex (IC), hippocampus, amygdala, and hypothalamus. In addition, plasma oxytocin levels are known to rise during sexual response, peaking during orgasm, indicating the neurohormonal involvement in this process.

Moreover, in decision-making processes related to sexual desire, research has shown that individuals are more likely to direct their gaze toward the body rather than the face. This suggests that bodily cues play a central role in directing sexual desire (Bolmont et al., 2014). Other studies have found that higher testosterone levels in healthy young men are associated with increased effort to attract sexual partners. Although elevated testosterone may influence sexual behavior preferences in romantic relationships, it does not necessarily support the formation of long-term bonds and emotional attachment (Durdiakova et al., 2017).

On the other hand, sexual desire is positively correlated with relationship satisfaction in romantic couples. Sexuality is considered a factor that helps initiate and sustain a partnership long enough to allow the formation of a durable attachment bond (Yovell, 2008). A study by Mostova et al. (2022) found that sexual satisfaction and love languages are independently associated with relational well-being. When couples experience alignment, or even divergence, in love languages alongside fulfilled sexual desire, increases in relationship satisfaction often follow. Sex tends to play a more central role at the beginning of a relationship, while emotional support becomes increasingly important over time. Therefore, it can be concluded that romantic love is not a singular entity, but rather the result of a complex interplay between various psychobiological components, including attachment and sexual desire.

Conflict in Love

Conflict in romantic relationships is a complex phenomenon with significant implications for individual psychological well-being. It is influenced by various factors such as attachment styles, jealousy, and beliefs about love. A study by Utami et al. (2022) revealed that partner phubbing, neglecting one's partner due to excessive focus on electronic devices, can negatively impact relationship satisfaction. This may be attributed to attachment styles, which can predict relational difficulties, especially when individuals experience heightened anxiety about their partner or the relationship itself (Mutiara & Ariana, 2022). When two individuals share a similar affective attachment, they may become mutually exclusive to a certain extent, fostering emotional dependence. If expectations are unmet, such dependency may result in relational conflict (Yovell, 2008).

Furthermore, a study by Rafi et al. (2020) utilizing functional magnetic resonance imaging (fMRI) explored how conflict influences the neural representation of romantic partners, as well as how mediation may assist in resolving such conflicts. Findings indicated that mediation improved conflict resolution, increased satisfaction with both the content and process of discussions, and reduced residual disagreement. These results provide empirical support for the positive role of mediation in romantic conflict resolution. Interpersonal conflict was found to alter the neural representation of romantic partners, marked by reduced activation in brain areas associated with romantic love, reward processing, and positive emotion.

Attachment in Love

Attachment in romantic relationships plays a critical role in emotional regulation and in reducing stress or threat responses. A study by Aghedu et al. (2021) demonstrated that romantic relationships can serve as a source of emotional security, helping to diminish physiological reactivity and enhance emotional control in individuals experiencing love, particularly when facing adverse situations. For example, watching emotionally disturbing films elicited milder physiological responses in individuals in romantic relationships compared to single individuals. Moreover, viewing pictures of one's partner can alleviate physical pain, while thinking about an attachment figure can reduce negative thoughts. These findings align with an fMRI study by Ubaldi and Fairhall (2021), which found that viewing familiar faces, including those of loved ones, automatically activates brain regions such as the precuneus, ventromedial prefrontal cortex (vmPFC), and amygdala, which are involved in memory retrieval and social cognition.

Further research has revealed that romantic attachment involves complex neurobiological processes that regulate emotion and social behavior. Bartels and Zeki (2004) found that these processes influence brain regions involved in social judgment, avoidance behavior, and the processing of negative emotions, while also activating areas associated with reward and motivation. Neurohormones such as oxytocin and vasopressin have also been shown to mediate attachment, not only in the context of maternal love but also in adult pair bonding, potentially affecting social memory and learning in humans (Bartels & Zeki, 2004). Additionally, romantic attachment is influenced by oxytocin signaling generated during social and sexual interactions, which coordinates activity across various brain regions responsible for evaluating the significance of social cues. This brain activity indicates that attachment promotes healthy social interaction, a function reflected in human neural activity, particularly within areas related to the reward system and feelings of pleasure (Blumenthal & Young, 2023).

Other studies have also found that romantic attachment activates brain regions associated with the reward system and emotional processing, such as the caudate nucleus and the ventral tegmental area (VTA), which are believed to serve an evolutionary purpose in supporting the maintenance and survival of the human species (Beauregard et al., 2008). Beauregard et al. (2008) further noted that such attachment not only fosters feelings of comfort and security but also reduces negative social judgments and emotional responses such as aggression and fear—underscoring the importance of attachment in fostering healthy social interactions. Additionally, hormone levels such as testosterone influence attachment styles. Higher testosterone levels in young men are associated with a decreased tendency to engage in emotionally intimate and committed relationships, a pattern commonly referred to as the EROS love style (Durdiakova, 2017). Maternal attachment, for example, is reflected in specific neural responses to their own infant's attachment behaviors, involving brain regions such as the orbitofrontal cortex (OFC) and the anterior insula. These areas play a crucial role in recognizing and responding to the emotional needs of their infants (Noriuchi et al., 2008).

The authors acknowledge several limitations in this article. First, the study utilized only three academic databases, ScienceDirect, Scopus, and ProQuest, which may have limited the scope and representativeness of the articles included. Second, the hormonal discussion in this study was limited to oxytocin, dopamine, and testosterone, thereby excluding other hormones that may also contribute to the broader process of love formation. Third, the articles analyzed included studies that were not always up-to-date, suggesting that recent developments in the neuropsychological study of love may not have been fully captured. This limitation may be attributed to the restricted range of databases and the use of less comprehensive keyword selection.

Conclusion

Love is a complex phenomenon encompassing multiple dimensions of human experience, including psychological, biological, cognitive, and emotional aspects. This study aimed to explore existing research findings in an effort to understand love from a neuropsychological perspective. The literature review identified several types of love: romantic love, maternal love, filial love, unconditional love, and friendship love. Romantic love involves sexual passion, attachment, and attraction, whereas unconditional love is characterized by genuine affection without expectations. Maternal love refers to the bond between mother and child, filial love denotes a child's love for their parents, and friendship love pertains to affection within peer relationships. Each type of love activates distinct neural patterns, highlighting their unique neuropsychological profiles. Oxytocin, dopamine, and testosterone play active roles in the neurochemical processes underpinning love. Furthermore, the brain's responses to others' faces involve complex neural processes across varying brainwave frequencies. These neural responses differ depending on the nature of interpersonal relationships and the type of love

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involved. The study also uncovered unique neuropsychological characteristics of love, such as the roles of sexual desire, conflict, and attachment. Overall, the distinctive features of love reflect the dynamic interaction between brain structures, hormones, and neurotransmitters in shaping emotional experiences. Based on these conclusions, several implications can be drawn. First, this literature review may serve as a foundation for future research on love and neuropsychology. Second, a deeper understanding of the neural activation patterns involved in love could contribute to the development of more targeted therapies for emotional and interpersonal difficulties. Third, knowledge about the roles of hormones such as oxytocin, dopamine, and testosterone in the love process could inform pharmacological approaches to addressing social and emotional bonding disorders. Lastly, this study may offer valuable input for future researchers to conduct more specific and applied investigations—thereby enriching our understanding of the neuropsychological dimensions of emotional experience and their potential applications in clinical contexts and individual well-being.

Statement of Interest

Both authors of the article declare that they have no conflict of interest in the publication of this article.

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