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## The Science of Romantic Love: Distinct Evolutionary, Neural, and Hormonal Characteristics

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# The Science of Romantic Love: Distinct Evolutionary, Neural, and Hormonal Characteristics

## **Peer Review**

This work has undergone a double-blind review by a minimum of two faculty members from institutions of higher learning from around the world. The faculty reviewers have expertise in disciplines closely related to those represented by this work. If possible, the work was also reviewed by undergraduates in collaboration with the faculty reviewers.

## **Abstract**

Romantic love is a psychological state that encompasses extreme euphoria and feelings of passion and intimacy for another individual. It can be characterized using Dr. Helen Fisher's system of evolutionary, neural, and hormonal profiles that are distinct from those of attraction and attachment, which are two additional love-related processes. A broad review of scientific articles, classic literature, and popular culture is employed to define romantic love, and to explore its distinct evolutionary, neural, and hormonal characteristics. The possibility of romantic love under special circumstances is then explored. The discussion is specifically focused on the prospect of love without physical contact as featured in Spike Jonze's 2013 film, *Her*. Results of this literature and research review support the theory that romantic love is an inebriating condition that suppresses judgment, and thus romantic love under these specific conditions is, indeed, possible. Throughout this composition, socio-cultural, evolutionary, psychological, and physiological theoretical perspectives are presented in an informal dialogue to make this topic accessible to an interdisciplinary audience.

## **Keywords**

Romantic love, attachment, attraction, evolutionary characteristics, neural characteristics, hormonal characteristics, classic literature, popular culture, *Her*.

## **Acknowledgements**

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## I. Introduction

“Falling in love is a crazy thing to do. It's kind of like a form of socially acceptable insanity,” Amy, best friend of Theodore Twombly in Spike Jonze’s new film *Her* states with wide eyes after Theodore reveals a few interesting details about his newfound, hot and heavy relationship.<sup>1</sup> Most shocking of these juicy facts is that his new love is not for a gorgeous, thrilling woman, but for his new telephone operating system. Yes, Theodore’s romantic fantasies had grown to include walking down the aisle, whispering under the covers, cuddling in the sand, and sharing a life with a cold, shiny piece of metallic beauty. Amy is correct in stating that love certainly is crazy, causing humans to find passion in places that are most unlikely – undesirable, even. But is this love that Theodore experiences realistic?

Can a human being truly experience romantic love when the possibility of physical contact is not even on the farthest horizon? In order truly assess this scenario, it is necessary to define romantic love and its scientific parameters. Romantic love is a biological rewards process that can be characterized by distinct evolutionary, neurological, and hormonal profiles and whose science can be explained to an interdisciplinary audience through evolutionary, psychological, physiological, and socio-cultural theoretical perspectives. Each of these disciplines is used as evidence throughout this composition to define romantic love and to, ultimately, explore the possibility of romantic love without physical intimacy.

## II. What is Love?

In order to characterize romantic love, it is essential to first define the specific parameters that constitute the general

physiological state known as “love”. Love can be first-kiss butterflies of nervous anticipation, a transient feeling of eternal bliss, a lasting memory of a whirlwind night-becomes-morning-becomes-lifetime, a marriage sealed by a diamond (it’s forever, you know), hand-holding and sentence-finishing while fearlessly strolling through the park into aging beauty... Simply stated by one researcher, “Love may be: a complex emotion--it is never a single feeling; an ambition; moral commitment; a private dynamic struggle; a deal; a stop sign to psychological inquiry”.<sup>2</sup> Love can be a feeling of euphoria that has inspired poets, musicians, filmmakers, authors, and artists alike to produce a number of culturally important masterpieces. After all, where would society be without classics like *Titanic* and *The Notebook* or cheesy love songs such as Maroon 5’s “She Will Be Loved?”

Love is critically important to humanity, yet it can be an uncomfortable subject of discussion for many modern physicians and psychiatrists because it is largely associated with the humanities rather than scientific research.<sup>3</sup> However, love is beginning to make a splash in the scientific community as its physiological mechanisms are becoming uncovered. Scientists are beginning to separate the wide spectrum of love into distinct categories, as in Sternberg’s Triangular Theory of Love and Helen Fisher’s classification system. Sternberg’s Triangular Theory of Love separates dimensions of love into three categories: Intimacy, passion, and

<sup>1</sup>*Her*, directed by Spike Jonze (2013; Los Angeles, CA: Annapurna Pictures, 2014), DVD.

<sup>2</sup>Stephen Levine, “What is Love Anyway?,” *Journal of Sexual and Marital Therapy* 31, no. 2 (2005): 143-51. DOI:

<http://dx.doi.org/10.1080/00926230590478005>

<sup>3</sup>Jeffery Hayes, “‘Well I Got a Few of My Own’: Therapists’ Reactions to Attraction, Sex, and Love in Psychotherapy,” *Journal of Clinical Psychology: In Session* 70, no. 2 (2013): 119–122. DOI:

<http://dx.doi.org/10.1002/jclp.22063>

commitment. Love is classified based on combinations of any of these categories.<sup>4</sup> Biological anthropologist Helen Fisher's classification system, on the other hand, is based on evolutionary, neurological, and hormonal distinctions and includes three processes: Attraction, romantic love, and attachment.<sup>5</sup> I have chosen to focus my discussion of love's scientific elements on Helen Fisher's system due to its relevance, simplicity, and attainability to interdisciplinary audiences. Within Fisher's system, attraction entails processes of sexual desire to encourage intraspecies mating, whereas attachment is a widely studied psychological occurrence of long-term relationship security. From the original ground-breaking attachment theory of Bowlby and Ainsworth that involves infants' patterns of closeness to their primary caregiver, attachment has been applied by Hazan and Shaver to adult marital relationships.<sup>6,7</sup> In a romantic context, attachment is a biosocial process of affectionate bond formation between two individuals that entails proximity, emotional support, mediation of self-exploration, and causation of "separation distress" when the presence of the significant other is threatened.<sup>8,9</sup> This process takes at least two

to four years to occur and it facilitates the partners' desire to remain close during the process of child-rearing.<sup>10</sup> Romantic love is an attachment-forming process, which encourages partners to be choosy in selecting a suitable mate. Romantic love is the most extreme and exciting of the three rewards-based romantic processes, and will be the main subject of discussion for the remainder of this composition.

### III. The Evolutionary Basis of Romantic Love

Speaking from an evolutionary theoretical approach, romantic love is born from a defined evolutionary basis that is not unique to human beings. From a scientific standpoint, the ultimate motivation of organisms of any species is to pass on unique hereditary information by reproducing viable offspring. Romantic love may have been among the emotion-motivated systems that evolved in order to facilitate this process.

Nearly all species possess the capability to experience attraction, which is the most primal of forms of love in Fisher's system of classification. However, initial feelings of attraction may morph into the more evolutionarily advanced process of romantic love when the subjective state of pleasure becomes involved in an appreciation for a partner. This distinction separates so called "cold choosers" from "hot choosers". The former classification of species includes insects and small mammals that display attraction to ornamental displays, but are unable to experience concurrent sensations of pleasure. In essence, mating for "cold choosers"

<sup>4</sup>Robert J. Sternberg, "A Triangular Theory of Love," *Psychological Review* 93, no. 2 (1986): 119-135.

DOI: <http://dx.doi.org/10.1037/0033-295X.93.2.119>

<sup>5</sup>Helen Fisher et al, "Defining the Brain Systems of Lust, Romantic Attraction, and Attachment," *Archives of Sexual Behavior* 31, no. 5 (2002): 413-9.

DOI: <http://dx.doi.org/10.1023/A:1019888024255>

<sup>6</sup>John Bowlby, *Attachment* (New York: Basic Books, 1969), 1-407.

<sup>7</sup>Mary Ainsworth and Silvia Bell, "Attachment, Exploration, and Separation: Illustrated by the Behavior of One-Year-Olds in a Strange Situation," *Child Development* 41, no. 1 (1970): 49-67.

DOI: <http://dx.doi.org/10.2307/1127388>

<sup>8</sup>Phillip Shaver and Mario Mikulincer, "Attachment Bonds in Romantic Relationships," *American Psychological Association* 17, no. 426 (2014): 273-290. DOI: <http://dx.doi.org/10.1037/14250-016>

<sup>9</sup>Cindy Hazan and Phillip Shaver, "Romantic Love Conceptualized as an Attachment Process," *Journal of Personal Social Psychology* 52, no. 3 (1987): 511-524. DOI: <http://dx.doi.org/10.1037/0022-3514.52.3.511>

<sup>10</sup>See note 8.

functions as a routine, rudimentary process, rather than the pleasurable process that it serves for “hot choosers”, such as humans.<sup>11</sup>

Attraction, for “hot choosers” can develop into romantic love. The simple state of attraction is based primarily on proximity, sex appeal, beauty, and cultural predilections.<sup>12</sup> However, to advance to the state of romantic love, several evolutionarily-evolved assessment factors come into play, including subjective perception of beauty that subtends the skin, reciprocity, analysis long-term compatibility, and assessment of similarity.

As for the latter qualification, assessment of similarity may be equally important as subjective exaggeration of beauty in encouraging romantic love. Although it is commonly stated that “opposites attract”, psychiatrist Thomas Lewis of University of California at San Francisco's School of Medicine hypothesizes that assessment of a partner's physical traits may be based largely on an evolutionary sense of familiarity that humans derive from their earliest infantile experiences. As one journalist states, “Love is reactive, not proactive, it arches us backward, which may be why a certain person just ‘feels right.’ Or ‘feels familiar’”.<sup>13</sup> Although this theory may sound somewhat Freudian, similarity provides the evolutionarily-important sense of social support, enabling individuals to feel accepted and secure in their beliefs.<sup>14</sup>

Moreover, reciprocity also evolved in humans to facilitate romantic love. When an individual receives flattery or positive social reinforcement, he or she is likely to respond positively.<sup>15,16</sup> This positive response escalates the progression of relationship-building.

In addition to reciprocity and the other aforementioned factors, assessment of long-term compatibility aids in initiating romantic love. At least on the female side of the equation, one such evolved mechanism is achievement of the female orgasm. From an evolutionary perspective, males are able to easily achieve orgasm during copulation due to their natural need to pass on their genetic material, whereas females, need not climax in order for fertilization to occur. Males who are patient and attentive to their partner's needs are more likely than self-focused males to assist their partner in achieving orgasm. Thus, some scientists believe that the fickle female orgasm has evolved to allow females determination of partner suitability and compatibility for a long-term relationship that includes romantic love and attachment.<sup>17</sup>

Each of these evolutionary assessment factors can commence romantic love, a process that consists of wild passion and mad insensibility. Romantic love has evolved in humans to last up to roughly four years – the approximate time it takes to raise a child through infancy. If partners survive

<sup>11</sup>Gregory Miller, *The Mating Mind: How Sexual Choice Shaped the Evolution of Human Nature* (New York: Double Day, 2001), 1-528.

<sup>12</sup>Robert Crooks and Karla Baur, *Our Sexuality* (Independence: Wadsworth, Cengage Learning, 2014).

<sup>13</sup>Lauren Slater, “So What Really is this Thing Called Love,” *National Geographic*, February 2006, 32-49.

<sup>14</sup>Susan Sprecher and Kathleen McKinney, *SAGE Series on Close Relationships: Sexuality* (Thousand Oaks: Sage Publications, Inc., 1993), 1-200. DOI: <http://dx.doi.org/10.4135/9781483326252>.

<sup>15</sup>Susan Sprecher, “Insiders’ Perspectives on Reasons for Attraction to a Close Other,” *Social Psychology Quarterly* 61, (2002): 287-300. DOI: <http://dx.doi.org/10.2307/2787031>

<sup>16</sup>Erin Whitechurch, Timothy Wilson, and Daniel Gilbert, “He Loves Me, He Loves Me Not...: Uncertainty Can Increase Romantic Attraction,” *Psychological Science* 22, (2011): 172-175. DOI: <http://dx.doi.org/10.1177/0956797610393745>

<sup>17</sup>David Puts, Khytam Dawood, and Lisa Welling, “Why Women Have Orgasms: An Evolutionary Analysis,” *Archives of Sexual Behavior* 41, no. 5 (2012): 1127-1143. DOI: <http://dx.doi.org/10.1007/s10508-012-9967-x>

the high-strung emotions and irrationality of this insane phase, love can develop into the most advanced form of attachment, which has evolved to enable couples to effectively and cooperatively raise their progeny beyond infancy and through childhood. As one journalist eloquently and accurately states, regarding the difference between romantic love and attachment, “If *Dracula*—the frail woman, the sensuality of submission—reflects how we understand the passion of early romance, the *Flintstones* reflects our experiences of long-term love: All is gravel and somewhat silly, the song so familiar you can't stop singing it, and when you do, the emptiness is almost unbearable”.<sup>18</sup> Romantic love clearly serves a distinct and fundamental evolutionary purpose.

### III. The Neurological Basis of Romantic Love

Taken from a rewards-based learning theory psychological approach, romantic love has a characteristic neurological profile. This profile is not easily separated from the neurological profiles of attraction and attachment, as all three stages can occur simultaneously and in a related manner. However, attachment is distinct in that it is primarily associated with activation of a functional region of the brain known as the ventral pallidum, which is associated with vasopressin-mediated pair-bonding.<sup>19,20</sup> Attachment is also associated with

deactivation of stress-related areas, including the right anterior insula, superior frontal gyrus, and hypothalamus.<sup>21</sup> Attraction, on the other hand, is distinct in that it is associated with activation of areas adjacent to primary romantic love activation areas, in addition to the hypothalamus, an area related to autonomic processing that is also activated in romantic love.<sup>22</sup> However, according to functional magnetic resonance imaging studies, romantic love is distinct from attraction and attachment in that it uses subcortical reward centers to focus on the lover-in-question, and limbic centers to process emotions related to this individual.<sup>23</sup> Romantic love activates the ventral tegmental area (VTA), a reward region that is associated with feelings of pleasure, general arousal, euphoria, focused attention, and motivation, and has been shown to be affected in situations involving cocaine, chocolate, and money.<sup>24,25,26,27</sup> Romantic love also activates the caudate nucleus, a

<sup>21</sup>See note 8.

<sup>22</sup>Semir Zeki, “Neurobiology of Love,” *ScienceDirect* 581, no. 14 (2007): 2575-2579. DOI:

<http://dx.doi.org/10.1016/j.febslet.2007.03.094>

<sup>23</sup>Arthur Aron et al., “Reward, Motivation, and Emotion Systems Associated with Early Stage Romantic Love,” *Journal of Neurophysiology* 94, (2005): 327-337. DOI:

<http://dx.doi.org/10.1152/jn.00838.2004>

<sup>24</sup>Arthur Aron, Helen Fisher, and Greg Strong, “Romantic Love” in *The Cambridge Handbook of Personal Relationships* (Cambridge: Cambridge University Press, 2006), 519-614.

<sup>25</sup>Wolfram Schultz, “Multiple Reward Signals in the Brain,” *National Review of Neuroscience* 1, (2000): 199–207. DOI: <http://dx.doi.org/10.1038/35044563>

<sup>26</sup>Mauricio Delgado, “Reward-Related Responses in the Human Striatum,” *Annals of the New York Academy of Science* 1104, (2007): 70–88. DOI: <http://dx.doi.org/10.1196/annals.1390.002>

<sup>27</sup>Rebecca Elliott et al., “Differential Response Patterns in the Striatum and Orbitofrontal Cortex to Financial Reward in Humans: A Parametric Functional Magnetic Resonance Imaging Study,” *Journal of Neuroscience* 23, (2003): 303–307. DOI: <http://dx.doi.org/10.1111/j.1411.3559>

<sup>18</sup>See note 13.

<sup>19</sup>Helen Fisher, Arthur Aron, and Lucy Brown, “Romantic Love: A Mammalian Brain System for Mate Choice,” *Philosophical Transactions B* 361, (2006): 2173-2186. DOI: <http://dx.doi.org/10.1098/rstb.2006.1938>

<sup>20</sup>Jessie Williams et al., “Oxytocin Administered Centrally Facilitates Formation of a Partner Preference in Female Prairie Voles (*Microtus ochrogaster*),” *Journal of Neuroendocrinology* 6, (1994): 247–250. DOI: <http://dx.doi.org/10.1111/j.1365-2826.1994.tb00579.x>

region associated with reward detection and representation of goals.<sup>28,29,30,31,32</sup>

In addition to the reward-related neuronal areas that are activated when an individual experiences romantic love, the neuronal profile of romantic love also includes deactivation of certain portions of the brain. Areas of the frontal cortex, parietal cortex, mid-temporal cortex, and amygdala are all shut down when romantic love takes the reigns of neuronal control. Deactivation of the latter portion translates to relaxation of inhibition. Relaxation of areas of the frontal cortex, on the other hand, equates to relaxation of judgment and reason. As physicist Blaise Pascal once stated, “the heart has its reasons of which reason knows nothing”.<sup>33</sup> Love literally inhibits functional reasoning, causing individuals to throw logic to the wind, neglect mundane responsibilities, or overlook fatal personality flaws in their perfect partners. In combination, deactivation of the amygdala and frontal cortex areas provide nature’s perfect concoction for falling madly in love. Yet, as German philosopher Nietzsche once wrote,

“There is always some madness in love. But there is always some reason in madness”.<sup>34</sup> Deactivation of essential neurological areas that is distinct to the neurological profile of romantic love serves the higher purpose of facilitating romantic love.

#### IV. The Neurochemical and Hormonal Basis of Romantic Love

From a physiological foundation, romantic love has a distinct neurochemical and hormonal profile. While attraction is associated primarily with the dopamine reward pathway, and attachment is related to release of the two posterior pituitary hormones, oxytocin and vasopressin, the hormonal profile of romantic love is a combination of the two. Oxytocin, dopamine, and serotonin are the major neurochemicals associated with romantic love, with vasopressin and luteinizing hormone functioning to a lesser extent as mediators of social bonding and female proprioception, respectively.<sup>35</sup>

Oxytocin plays the most significant role in the hormonal profile of romantic love. This peptide hormone is formed in the hypothalamus and released from the posterior pituitary gland to reward-associated areas, including the nucleus accumbens and the prelimbic cortex (in contrast to vasopressin, which is released mainly to the reward-related ventral pallidum to reinforce oxytocin in the attachment-forming process, but has the main physiological role of promoting water reabsorption in the kidney).<sup>36</sup> Oxytocin is well-known for its release during childbirth and breastfeeding, but it has been more recently recognized for release during

<sup>28</sup>Mario Beauregard et al., “The Neural Basis of Unconditional Love,” *Psychiatry Research* 172, no. 2 (2009): 93-8. DOI:

<http://dx.doi.org/10.1016/j.psychres.2008.11.003>

<sup>29</sup>See note 25.

<sup>30</sup>Chantal Martin-Soelch et al., “Reward Mechanisms in the Brain and their Role in Dependence: Evidence from Neurophysiological and Neuroimaging Studies,” *Brain Research Reviews* 36, (2001): 139–149. DOI: [http://dx.doi.org/10.1016/S0165-0173\(01\)00089-3](http://dx.doi.org/10.1016/S0165-0173(01)00089-3)

<sup>31</sup>John Lauwereyns et al., “Feature-Based Anticipation of Cues that Predict Reward in Monkey Caudate Nucleus,” *Neuron* 33, (2002): 463–473. DOI: [http://dx.doi.org/10.1016/S0896-6273\(02\)00571-8](http://dx.doi.org/10.1016/S0896-6273(02)00571-8)

<sup>32</sup>John O’Doherty et al., “Neural Responses During Anticipation of a Primary Taste Reward,” *Neuron* 33, (2002): 815–826. DOI:

[http://dx.doi.org/10.1016/S0896-6273\(02\)00603-7](http://dx.doi.org/10.1016/S0896-6273(02)00603-7)

<sup>33</sup>Blaise Pascal. *Pensées* (London: Penguin Classics, 1995), 1-368.

<sup>34</sup>Friedrich Nietzsche. *Thus Spoke Zarathustra* (Saint Paul: Thrifty Books, 2009) 1-252.

<sup>35</sup>See note 19.

<sup>36</sup>Thomas Insel, “Is Social Attachment an Addictive Disorder?,” *Physiology and Behavior* 79, (2003): 351-357. DOI:

<http://dx.doi.org/10.3109/00952990.2010.495183>

processes of social bonding, orgasm, and maternal behavior.<sup>37</sup> Within these processes, oxytocin facilitates trust, social bonding, and monogamy.<sup>38,39</sup> It has been shown to be present at highest serum concentration in individuals who are “falling in love”, and has been shown to increase during nonverbal displays of romantic love in individuals in new relationships.<sup>40,41</sup>

Perhaps more significant than the presence of oxytocin in facilitating romantic love is its absence in social mental disorders, including autism and various addictions.<sup>42,43,44</sup> Decreased levels of oxytocin are also present in individuals in

waning or stressful relationships, which includes a profile of increased levels of stress-associated adrenocorticotrophic hormone, norepinephrine, and epinephrine in individuals experiencing troubled marriage.<sup>45</sup> Thus, treatments that involve increasing levels of oxytocin show promise in mediating social disorders and unexciting romantic relationships alike. Oxytocin may be a more potent love potion than any aphrodisiac. Already, it has been marketed in perfumes called “trust elixir”, which are laced with an oxytocin agonist. Moreover, it has been tested as an intranasal spray to facilitate feelings of love between partners.<sup>46,47</sup>

Dopamine is also active in the neurochemical and hormonal profile of romantic love. This catecholamine neurotransmitter is known for its role in balance, problem solving, and – most importantly – reward-motivated behavior. It is released from the VTA or substantia nigra and works on areas of the brain including the midbrain (nigrostriatal/balance function), nucleus accumbens, amygdala, hippocampus (mesolimbic/rewards function) and frontal cortex (mesocortical/logic function) in a fashion similar to euphoric opioid drugs such as cocaine.<sup>48</sup> In essence, dopamine’s most substantial role is to take an individual from “liking” to “wanting” a substance or another individual.<sup>49</sup> Dopamine plays a role not only in immediate reward recognition,

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<sup>37</sup>Navneet Magon and Sanjay Kalra, “The Orgasmic History of Oxytocin: Love, Lust, and Labor,” *Indian Journal of Metabolic Endocrinology Suppl* 3, (2011): S156-61. DOI: <http://dx.doi.org/10.4103/2230-8210.84851>

<sup>38</sup>Dirk Scheele et al., “Oxytocin Modulates Social Distance Between Males and Females,” *The Journal of Neuroscience* 32, no. 46, (2012): 16074-9. DOI: <http://dx.doi.org/10.1523/JNEUROSCI.2755-12.2012>

<sup>39</sup>Dirk Scheele et al., “Oxytocin Enhances Brain Reward System Responses in Men Viewing the Face of their Female Partner,” *Proceedings of the National Academy of Sciences of the United States of America* 110, no. 50, (2013): 20308-13. DOI: <http://dx.doi.org/10.1073/pnas.1314190110>

<sup>40</sup>See note 37 above.

<sup>41</sup>Gian Gonzaga et al., “Romantic Love and Sexual Desire in Close Relationships,” *Emotion* 6, no. 2, (2006): 163-79. DOI: <http://dx.doi.org/10.1037/1528-3542.6.2.163>

<sup>42</sup>Eric Hollander et al., “Oxytocin Infusion Reduces Repetitive Behaviors in Adults with Autistic and Asperger's Disorders,” *Neuropharmacology* 28, no. 1, (2008): 193-198. DOI: <http://dx.doi.org/10.1038/sj.npp.1300021>

<sup>43</sup>Eric Hollander et al., “Oxytocin increases retention of social cognition in autism,” *Biological Psychiatry* 61, no. 4, (2008): 498-503. DOI: <http://dx.doi.org/10.1016/j.biopsych.2006.05.030>

<sup>44</sup>James Leckman et al., “The Role of Central Oxytocin in Obsessive Compulsive Disorder and Related Normal Behavior,” *Psychoneuroendocrinology* 19, no. 8, (1994): 723-749. DOI: [http://dx.doi.org/10.1016/0306-4530\(94\)90021](http://dx.doi.org/10.1016/0306-4530(94)90021)

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<sup>45</sup>Janice Kiecolt-Glaser et al., “Lover, Marriage, and Divorce: Newlyweds’ Stress Hormones Foreshadow Relationship Changes,” *Journal of Consulting and Clinical Psychology* 71, no. 1, (2003): 176-88. DOI: <http://dx.doi.org/10.1037/0022-006X.71.1.176>

<sup>46</sup>See note 37.

<sup>47</sup>Olga Wudarczyk et al., “Could Intranasal Oxytocin be used to Enhance Relationships? Research Imperatives, Clinical Policy, and Ethical Considerations,” *Current Opinion in Psychiatry* 26, no. 5, (2013): 474-84. DOI: <http://dx.doi.org/10.1097/YCO.0b013e3283642e10>

<sup>48</sup>See note 22.

<sup>49</sup>See note 36.

but also in promoting longer-term reward processes of romantic love, as evident in studies on prairie voles, animals among the few monogamous rodent species. It has been shown that injection of a D<sub>2</sub> receptor dopamine antagonist into the nucleus accumbens of female voles causes them to form fleeting sexual encounters with male voles. Conversely, injection of a D<sub>2</sub> receptor dopamine agonist with concurrent restriction of sexual activity facilitates monogamy.<sup>50</sup> It is thus evident that love plays a distinct role in causing partner preference.

Dopamine release in romantic love has been shown to be enhanced by high oxytocin levels and by low serotonin levels.<sup>51,52</sup> The latter of these neurochemicals is a monoamine transmitter that is released from raphe nuclei within the brainstem and activates the nucleus accumbens, frontal cortex, cortex, or neurons within the spinal cord to cells within the GI tract among other locations. Its release functions in regulating mood, appetite, memory, sleep and cognition, perhaps contributing to the lack of hunger and fatigue experienced during romantic love.<sup>53</sup> Studies have shown that, in patients who have “fallen in love”, serotonin levels are decreased to levels measured in individuals with obsessive compulsive disorder. As one researcher states, “Love, after all, is a kind of obsession and in its early stages commonly immobilizes thought

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<sup>50</sup>Brendan Gingrich et al., “Dopamine D2 Receptors in the Nucleus Accumbens are Important for Social Attachment in Female Prairie Voles (*Microtus ochrogaster*),” *Behavioral Neuroscience* 114, (2000): 173-183. DOI:

<http://dx.doi.org/10.1523/JNEUROSCI.5039-08.2009>.

<sup>51</sup>See note 22.

<sup>52</sup>See note 39.

<sup>53</sup>Tempestt Gilmore et al., “Methamphetamines: An Overview,” Macalester Academics, access date January 2015,

<http://www.macalester.edu/academics/psychology/w/hathap/ubnrp/meth08/homepage.html>

and channels it in the direction of a single individual”.<sup>54</sup> It follows that if oxytocin is the ultimate love potion, serotonin is the ultimate anti-love drug. Prozac, a selective serotonin uptake inhibitor (SSRI), has been linked to diminished libido. The decision to diminish use of Prozac or other SSRIs has been reported to save marriages from divorce, or conversely, the decision to commence SSRI use has pushed passionate relationships into hot-blooded boredom. As one journalist states, “there is hope, for those caught in the grip of runaway passion—Prozac. There's nothing like that bicolored bullet for damping down the sex drive and making you feel ‘blah’ about the buffet”.<sup>55</sup> It is therefore evident that oxytocin, dopamine, and lack of serotonin each play distinctive roles in the neurochemical and hormonal profile of romantic love.

## V. Distinct Attributes of Romantic Love: Love without Physical Contact

Does the distinct evolutionary, neurological, and hormonal profile of romantic love allow for love in certain unique circumstances, such as love without physical contact? It can be argued that experiencing romantic love without physical contact would be a disadvantage from an evolutionary standpoint as love in this manner eliminates the possibility of gene transfer to future generations. Yet love without physical contact fits the evolutionary profile of romantic love in that, as in the case of Theodore and his operating system in *Her*, individuals in this type of relationship are nonetheless advancing beyond the stage of attraction through a process that includes determination of long-term compatibility, similarity, reciprocity, and subjective perception of beauty, with reproduction of impossible, yet nevertheless

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<sup>54</sup>See note 22.

<sup>55</sup>See note 13.

fantasizable offspring who possess desired traits in the back of their minds.

Moreover, from a rewards-based learning theory psychology perspective, the neurological and hormonal profiles of individuals experiencing romantic love offer support for the possibility of romantic love in such unique circumstances. After all, romantic love deactivates critical areas for appropriate judgment in its neurological profile, allowing individuals to overlook obvious flaws in their lovers, such as the absence of a body in *Her*. Moreover, as previously stated, the physiologically substantiated neurochemical and hormonal profile associated with romantic love is akin to that of an addict or OCD patient when it comes to thoughts about the individual's lover, again which can facilitate states of irrationality and improper judgment. Thus, as long as initial attraction is present, evolutionary, neurological, and hormonal profiles associated with romantic love can outweigh the hard facts of evolutionary rationale and facilitate the presence of romantic love in unique circumstances, such as love without physical contact.

But how can initial attraction be possible without a physical body? Pure physical attraction is not exclusive in mediating attraction. As previously stated, proximity, sex appeal, beauty, and cultural predilections each play roles in facilitating this psychological state. Although the operating system in *Her* may not be considered beautiful, she is undeniably in close proximity to Theodore, she possesses all personality traits that allow for culturally typical social interactions, and she has inherent sex appeal even without a physical presence. Voice can undoubtedly be an integral part of sex appeal. Why else would Americans continue to use Sinatra's smooth tunes during classy date nights? Deep, husky male voices, like that of Sinatra, are rated as most appealing females, while high-pitched,

breathy voices, like that of Marilyn Monroe and Scarlet Johansen, the voice of the operating system in *Her*, are rated as most appealing to males.<sup>56</sup> When Theodore listens to Johansen's attractive tone, he falls instantly and deeply into romantic love, in a manner that is atypical due only to her absence of a physical being. Theodore's romantic love for his operating system in *Her* fits the basic profile of romantic love that are defined by evolutionary, psychological, and physiological disciplines, and is in essence a unique spin on a beautiful biological process.

## VI. Conclusion

Romantic love has a distinct evolutionary, neurological, and hormonal profile that allows for its potential in certain unique circumstances, such as love without physical contact. Within Helen Fisher's unique classification system, romantic love falls with attraction and attachment under the umbrella of "love" – a difficult-to-define physiological process involving a wide spectrum of euphoric, rewards-motivated emotions caused by strong feelings toward another individual; a state of being that has inspired generations of poets, musicians, filmmakers, authors, and artists since the birth of human interaction. Love is furthermore a concept that can be appreciated by an interdisciplinary academic community, including evolutionary, psychological, physiological, and socio-cultural, theoretical perspectives.

Romantic love specifically can be defined as a psychological state that encourages partners to be choosy in selecting a suitable mate and is the most extreme and exciting of these systems of emotion. Evolutionarily, romantic love is unique in that it serves the purpose of

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<sup>56</sup> Molly Babel et al., "Toward a More Nuanced View of Vocal Attractiveness," *PLOS One* 9, (2014) 1-10. DOI: <http://dx.doi.org/10.1371/journal.pone.0088616>

advancing partners beyond attraction to attachment via a process of assessment in order to ensure production of successful offspring. Neurologically, the profile for romantic love features activation of reward centered areas as well as deactivation of areas associated with fear and reason. Lastly, the neurochemical and hormonal profile of romantic love is unique in its involvement of bonding-related oxytocin release, reward-related dopamine release, and addiction-associated serotonin inhibition.

The evolutionary, neurological, and hormonal profiles mutually combine to support the potential for romantic love in all types of uniquely impractical circumstances, such as the romantic love without physical contact featured in the film *Her*. From *Titanic* to *The Notebook* to “She Will Be Loved” to *Dracula* to *The Flintstones* to *Pensées* to *Thus Spoke Zarathustra* to “Fly Me to the Moon” to *Some Like it Hot* to, of course, our prime example *Her*... Romantic love has undoubtedly played a role in socio-cultural expression throughout history. Yet today, this subject of human fascination is beginning to take on a multidisciplinary role as its mechanisms are becoming evolutionarily, psychologically, and physiologically uncovered. Its wide discussion within the eager scientific community, as is possible in the context of our deliberation of *Her*, is a milestone worth celebrating with a sappy iRomance hot and freshly downloaded onto our precious phones.