

Love is a physiological motivation (like hunger, thirst, sleep or sex)

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ABSTRACT

The multitude of terms associated with love has given rise to a false perception of love. In this paper, only maternal and romantic love are considered. Love is usually regarded as a feeling, motivation, addiction, passion, and, above all, an emotion. This confusion has consequences in the lives of human beings, leading not only to divorces, suicides, femicides but possibly also to a number of mental illnesses and suffering. Therefore, it is crucial to first clarify what is meant by emotion, motivation and love. This work aims to finally place love within the category of physiological motivations, such as hunger, thirst, sleep, or sex, on the basis that love is also essential for human survival, especially in childhood. Love is presented from an evolutionary perspective.

Some other similarities between love and other physiological motivations are pointed out, such as its importance for appropriate human development, both its ontogeny and its permanence, and the long-lasting consequences of abuse and neglect. There are summarized reasons that account for this, such as the fact that physiological motivations are essential for survival and that love is an essential motivation for the survival of human offspring. Other reasons are that minimum changes in the quantity and quality of love alters development, that there can be a variety of neurophysiological and behavioural states within a motivation, and that motivations (also love) appear and change throughout development. Also, motivations and love sometimes may lead to an addictive behaviour. Finally, it is recognized that once physiological motivations (and love) appear, they become permanent.

In a third section, some potential social, cultural, clinical and scientific consequences of the proposed consideration of love as a motivation are discussed. Accordingly, love's recognition as a motivation in the clinical field would imply a better understanding of its disorders and its inclusion in classifications manuals such as *The Diagnostic and Statistical Manual of Mental Disorders* (DSM), or in the *International Classification of Diseases* (ICD). Considering love as a motivation rather than an emotion could also impact the results of scientific research (an example is included).

A comprehensive understanding of these questions could potentially allow for a new therapeutic approach in the treatment of mental illness, while offering an all-inclusive evolutionary explanation of cultural phenomena such as the origin and diffusion of both language and art. Love should be understood as a physiological motivation, like hunger, sleep or sex, and not as an emotion as it is commonly considered.

Introduction

Research into the nature of love has enabled us to understand most of its characteristics and neurobiological basis. However, the general cultural interpretation that love is an emotion contributes to confusing the conclusions drawn about it. This confusion occurs when authors want their results to fit within the present social paradigm of love, where it is mainly considered to be an emotion.

In a first section, the concepts of emotion, motivation and love are briefly described, to then justify—second section—the consideration of love as a motivation.

In a third section, some potential clinical, social, cultural, and scientific consequences of the proposed consideration of love as a motivation are discussed.

What is it an emotion?

An emotion is a generally short—in the order of seconds or minutes [1,2]—physiological [3,4] and behavioral [5,6] response of variable

intensity or arousal [7]. It is accompanied by a specific mental state [8], and is usually activated by external stimuli—not, for example, during sleep [9]—.

Emotion is not only a state associated with measurable physiological changes, but also with patterns of neural activation [10] that could be relatively specific to each emotion [11], although this is still under discussion [12–15]. Thus, it has been suggested that the different emotions result from different activation patterns within a shared neural circuit, mostly consisting of midline regions, motor areas and subcortical regions, which allows to differentiate positive emotions, basic negative emotions, social negatives, and surprise [16].

Although the nature, categories and functions of emotions are in constant debate [17–19], their evolutionary usefulness in the survival of species [20]—such as *disposition for action* [21]—is generally accepted [22]. There is also consensus in differentiating some basic, or primary, emotions shared by humans and animals—*disgust, anger, fear, happiness, sadness, and surprise* [23]—from other, secondary emotions such as *shame* or *gratitude* [6], which are present to a lesser degree in other species. It must be noted that animals that are not

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phylogenetically close to humans, like horses, can recognize some emotional expressions in humans [24].

In human evolution, the phenomenon of progressive maternal dedication to increasingly immature offspring may have been associated with a gradual increase in the intensity of the emotions associated with maternal-child interaction (breastfeeding pleasure and joy, fear and pain in separation and loss). This evolutionary root of love building is responsible for the generalized consideration of love as an emotion. In fact, love between adults is usually considered as an emotion associated with sexual interest [25–27].

On the other hand, sexuality can also be accompanied by strong emotions. The extreme, required physical proximity triggers and heightens these associated emotions. However, sexual motivation is not an emotion. Whilst romantic touch by a partner elicits a brain response [28], neither sex or love are emotions [1,26,29]. Still, the extreme emotions associated with sex drive are often interpreted as love. Hence, in many societies love is confused with a simple emotion accompanying sex drive. Consequently, *when researchers ask participants to list states they consider emotions, love is typically near the top of that list* [25,30], in [26].

Furthermore, the current interpretation of love in the scientific field is clearly reflected, above all, as an emotion or feeling: *Love is one of our most powerful emotions* [31] Table 1.

What is a motivation?

Physiological motivations are the diverse mechanisms that, in a permanent way, assure an efficient maintenance of the metabolic processes essential for the survival of the individual and the species. These include the acquisition of nutrients [40], water [41] or reproduction. *Evolution, especially natural selection, determines which motivated behaviors are useful* [42]. The main differentiating attribute of the

Table 1

Love is usually considered as an emotion.

Several searches were performed aimed at clarifying the general interpretation of love in the scientific field. A literature search on “love” in Pubmed on March 3, 2019 returned 17,345 results. When using the terms “love, emotion”, the search generated 3986 references; whereas using “love, feeling”, the search produced 4071 references. In contrast, when searching for the terms “love, motivation”, there were 777. Despite this search being an indirect index without additional filters or meta-analysis, the results show a scenario that seems to clearly reflect a scientific interpretation of love in particular as an emotion or feeling. In many of these excellent investigations love is understood as an emotion, for example:

... prosocial emotions (love, compassion, gratitude, and admiration) ... [32];

... Thirteen positive emotions were examined, namely, amusement, awe, challenge, compassion, contentment, gratitude, hope, interest, joy, pride, relief, romantic love and serenity ... [33];

... EEG correlates of ten different positive emotions (joy, gratitude, serenity, interest, hope, pride, amusement, inspiration, awe, and love) ... [34];

... eight positive emotion constructs – amusement, awe, contentment, gratitude, interest, joy, love, and pride ... [35]

... listening to liked music evoked positive emotions (enjoyment, happiness, love, and satisfaction), while disliked music elicited negative emotions (disappointment, and disgust) ... [36];

... a five-factor TEI (teacher emotion inventory) model was identified with two positive factors (Joy and Love) and three negative factors (Sadness, Anger, and Fear) ... [37];

... processing the meaning of abstract emotion words as, for example, ‘love’ ... [38].

...We combined the intensity ratings related with positive emotions (joy, satisfaction, pride, love, passion)... [39]

Of course, the mentioned authors do not refer to love exclusively as an emotion. One of the anonymous reviewers of this article summarizes with an exquisite precision the universal interpretation of love: *“Love is a blend of emotions, feelings, behaviors, cognitive processes and motivation, colored by the personal genetics, experiences and shaped by cultural contexts in its more overt expressions”*.

motivations regarding emotions is their permanence throughout the whole life of the individual although, behavioral and physiologically, the motivation is evidenced only at specific moments in which some physiological indicator moves away from equilibrium, or *homeostasis*. From Psychology, a distinction must be made between the behavioural component of motivation, the stimuli or keys that facilitate or inhibit motivated behaviour, and the triggers of such behaviour [43]. From current Neurosciences, *behaviour* may be the physiological, cellular and molecular aspects that are gradually known.

Thus, for example, the maintenance of brain [44] and body [45] temperature in homeothermic animals is achieved through different actions depending on whether the environment is cold or warm; these include transpiration, panting, tremor, and others. Although this motivation is inexorably linked to homeostasis, it may not be continuously evident in the behavior, which may in turn hinder detection and understanding of it. Even in cold-blooded animals, this motivation can guide the behavior of animals, for example, by making worker bees flap their wings in the hive [46–48]. However, they are not always flapping their wings.

Strictly speaking, hunger or thirst do not constitute physiological motivations. They are rather the impulse that leads to maintaining the balance of the *milieu interior* [49]. Hunger and thirst, or the beating of the wings, are the consequences of an imbalance in *homeostasis* [50] which can become dangerous and even deadly. In the same way that human beings are always accompanied by the need for food and water, for sleep, or for maintaining body temperature, they are also accompanied by the need for love.

Therefore, love should be considered to be like food, water or sleep, because it accompanies people from birth to death. In exactly the same way that mammals initially feed the young with milk before specializing the diet according to species, love develops into individual attachment styles through maternal-infant interaction, which are then transferred to one's adult sentimental relationships [51–54].

With survival being the primary aim of existence, many physiological functions often collaborate to achieve it. In addition to different motivations interacting with each other, such as sexuality and food intake [55], interaction likewise occurs between motivations and emotions [56,57]. A fight for food may cause aggressive behaviour tainted by raw emotions, but hunger is not an emotion. Sleep alters the babies' behaviour and may makes them more irritable, but sleep is not an emotion. Thirst makes animals approach the river, and their behaviour becomes much more cautious and fearful in the presence of crocodiles, but thirst is not an emotion. A recent controversy about fear emotional conceptualization and terminology may be found in [58–61].

There are also a number of psychological motivations, especially conceptualized by various researchers and theorists of the twentieth century (Maslow, McClelland, Herzberg, Amsel, and others). Categories such as *extrinsic* and *intrinsic* motivations are distinguished, as are specific motivations, such as security or esteem. An example of excellent proposals aimed at the unification of all motivations is that of Dr. David Forbes [62].

For example, in Dr. Abraham Maslow's well-known pyramid of needs [63,64], the first step is constituted by the basic physiological motivations, on which the need for security—the second need—would rest, followed by that of belongingness—the third need—where love would be included. Then, the need for self-esteem would follow and finally, the achievement of the purpose and acceptance of oneself. The impact of Maslow's hierarchical relationship of needs has been enormous in the field of health research and training [65], and remains so [66]. One of the objectives of the Maslow's pyramid is to contribute to the design of professional and educational strategies that promote happiness. In this sense, it is worth mentioning a study that discovered how students of both sexes chose the fact of falling in love or staying in love significantly more than the other needs to find happiness [67].

The current article proposes to establish love as a human basic physiological motivation¹, rejecting its consideration as a temporary emotion.

What is love?

The continuous reference to love in the realizations of culture—music, literature, television, films, among others—teaches us to live a love dominated by emotion, language and thought. Throughout the last centuries, reference has been made to a love under control, such as *courteous love, compassionate love, love of work, selfless love, love for others, sacrificial love, love for children, love for God, love for parents, love of money, love of sports, love to the party*, etc. This multitude of terms associated with love has ended up creating a false perception of love as anything that may be more or less controlled by the human mind. In fact, most of these loves are hobbies that can fill a stage of our lives. In the current article, *only love for humans*—maternal love, romantic love, even grandmother love—is considered.

A similar polysemy occurs with hunger. In addition to its relation to food, there is also talk about hunger for success, hunger for power, possessions, or conquests. Thirst can also be associated with obtaining something, such as revenge or blood. However, there is a fundamental difference between hunger or thirst and love in that, while *hunger and thirst are not motivations*—but rather the consequence of a momentary imbalance in homeostasis—love is defended in this article as a physiological motivation.

Normally we do not experience hunger or thirst, but they rather emerge after regular intervals in absence of food or water intake. Although hunger and thirst appear punctually, the underlying physiological motivation is permanent. Similarly, fear, surprise or anger appear punctually while the need for love is permanent, as the need for food, water, or sleep.

While some works correctly differentiate the emotional vs. motivational components of love [26,74–77], on occasion the distinction is not sufficiently clear. These works include related terms such as feeling [78–81]—mental experiences that accompany body states and may be elicited by drives or emotions [82]—, passion [83], devotion or attachment [84] and, of course, emotion, which is probably the most used term to describe love [25,31–39,84–87].

In the classical typology of love [88], the *Eros* style is passionate or romantic love, with intimate, sexual activity and intense feelings. Commitment, one of the suggested basic pillars of love [89,90], and friendship, which would correspond to the style of *Storge* (friendship-love), could be more valued in some cultures [91] than in others [92]. The concept of love also varies according to age group. Thus, while younger people may prefer the *Eros* style, they would later opt for the style of love which favors commitment (*Storge*) and attachment [93], and also the more rational styles (as *Pragma*) [94].

It seems that love could also include almost any component, for example, motivational, such as sexual motivation—*Eros*—, but also of will, passion and reason—*Pragma* [89]. Really, love and sex are different things [26,77]—differentiated motivations—but, in general, people [25] and scientists [33–37] interpret love as an emotion, even considering the well-known relationship between emotion and cognition [95].

Whether love is considered technically to be an emotion or a motivation is not simply a question of terminological precision, of interest only to scientists and researchers. On the contrary, its repercussions are

¹ At present, any mental function and motivation of a psychological nature may be explained in terms of physiological, genetic and biochemical processes, and be placed in specific brain structures and networks, for example, morality [68], prestige or reputation [69], creativity [70], feeling confident [71], safety and self-esteem [72,73]. Therefore, physiological and psychological motivations are equally physiological.

numerous and transcendental across all fields, whether theoretical or in research, basic or applied. This is especially true in the clinical field, for example, when relationships among love, sex, and addiction are discussed [96–102].

As Dr. Joseph LeDoux states, “*Emotion, motivation, reinforcement and arousal are closely related topics and often appear together in proposals about emotion*” [78]. This article summarizes arguments that allow understanding love as a motivation.

Physiological motivations are essential to survival

Evolution determines which motivated behaviours are useful [42]. The ultimate and essential motivation is survival; other motivations are differentiated by the concrete impulses and the permanent behavioural patterns particular to each species or specimens. According to our present understanding, the survival of the individual and the survival of the species are very similar. In both cases, the species requires the genetic implementation of the motivation in the individual so as not to become extinct. The species does not comprise only the body and the observable behaviour, but also the visceral and cerebral physiology, including its specific motivations.

In this article, love is proposed to be considered as a physiological motivation. In order to determine this, it must be first determined whether love is necessary for the survival of the species and for its specimens. As physiological motivations ensure survival—a detailed description of brain survival circuits may be found in [78]—, one essential question to answer is whether love is necessary for human survival. Another question pertains whether love is permanent like all other motivations.

Love is an essential motivation for the survival of human offspring

Especially during the first stages of life, a human baby abandoned by its mother will die (in the absence of sanitary and social assistance). This also applies to the young of many animal species [103]. Even in developed countries it has been found that parental death in childhood or adolescence is associated with increased all-cause mortality into early adulthood [104]. Thus, the lack of love is equal to the lack of food and water or to the loss of thermoregulation. Food, water, shelter and love are exogenous factors that are equally essential to survival. In mammals, lactation brought about a greater level of dependency in the young with respect to the mother than occurred in previous animals. The total absence of either motherly love, food, or water, causes death, and in the worst case, the extinction of the species.

The necessity of love for the survival of the human species is especially relevant when considering the total dependence of human offspring on parental care. This dependence is due to the offspring's immaturity, which results from an extended brain developmental process accompanied by a gradual increase in the duration of childhood in the last million years [105,106]. Within this period, a concentrated amount of love increased in the hominid line of evolution via natural selection.

This increase was due to the fact that only mothers who attended their babies transmitted their genes and behaviours. The underlying motivation is love, not the care, feeding or transportation of the baby, which only are some of the *behaviours generated by love*. Love is essential for human survival, and so, love may be the X-factor that explains human evolution, as in the Dr. Derek Bickertońs question [107].

Alterations in the quantity and the quality of love, alters development

The parallel between the motivations also remains when considering changes in the quantity and quality of the amounts of both nutrients and love rather their complete lack. Similar effects on development occur concerning disturbances and deficiencies that can affect any motivation. Therefore, months and years of diets deficient in

essential nutrients may slowly lead to deficiency, illnesses and death—for example, for vitamin D [108]—, as does the lack of love during development.

Just as the lack of nutrients or sleep cause serious disturbances to the mind, so too, does the lack of love, even prenatally [109–111]. In addition, breakups, separations and divorces have been associated with higher incidences of mental and physical illnesses, or the worsening of previously existing illnesses [112–114].

Numerous studies and discoveries exist concerning the consequences of the neglect or lack of care during development, and of ill treatment and abuse, whether physical, verbal or sexual [115–117]. Several recent, extensive reviews have established the necessity of maternal love with care and affection during brain development [118,119]. Many of these discoveries confirm and extend the original works of Dr. Harry Harlow and colleagues [120,121]. They showed the effects of isolation and separation in young monkeys with surrogate mothers of wire and milk suppliers, or plush covers: *Most of the motherless mothers either completely ignored or abused their initial offspring* [122], and of the functions of attachment proposed by Dr. John Bowlby [123–125].

Today, in addition to the behavioral consequences of maternal abuse and neglect, the underlying genetic [126], electrophysiological [127,128] and neuroanatomical [129] mechanisms are beginning to be known. This has made it possible to obtain recently the first evidence that a psychosocial intervention program, which targets mothers at risk for abusive parenting, associates with variation in the DNA methylome in human adult offspring almost three decades later [130]. Above all, these investigations allow us to begin *to understand the plasticity of the brain circuits and structures involved in love and its permanence in time*.

Love surely is the main force responsible for the evolution of humanity, and the understanding of love as motivation may help explain many unresolved aspects of the process of hominization: *what makes us human?* [131], or, *where do human minds come from?* [132].

Motivations (also love) appear and change throughout development

Motivations appear and change in differing ways throughout development. Whilst *hunger* and *thirst* are satisfied by the intake of different substances after breastfeeding has ended, immediately after birth these are *undifferentiated* motivations. Another motivation, *sleep*, occupies almost the entire life of the newborn but gradually decreases until senescence. Finally, the *sex drive* develops from puberty onwards.

This demonstrates that physiological motivations appear and change throughout the course of life, and so too does love. In the first stage of our life, as with the rest of the motivations, love is essentially demanding – children demand attention, care, cleanliness and affection; and maternal love promote these behaviors and feelings impelled by internal rewards through the mesolimbic dopaminergic and oxytocinergic systems, as in romantic love with tiny differences [87,133,134].

Subsequently, the love motivation offers and demands affection, joy, support, generosity, company, etc. In short, love offers *happiness*² throughout life. That couples generally experience more happiness than single people do provides evidence of this [135].

It is understood in this article that the continuity between parental love and romantic love is based on attachment styles, which are developed through mother-child interaction and then transferred to romantic relationships [53,54,93,94,136,137]. Attachment theory has been extended to explain certain close, romantic love in adulthood [53], in [138].

Because of this, it is here proposed to consider love as a motivation

² It should be understood that the term "*happiness*" does not refer only to a subjective state of well-being, fullness, generosity and joy, but to an underlying physiological brain state in certain circuits [139], in the same way that "*sleep*" may be associated to certain parameters of brain activity [140].

that accompanies the human being throughout life under different modalities (baby attachment, maternal love, romantic love), in the same way that sleep or food intake consist of different components.

Thus, during sleep a number of behaviours have been described, such as REM and non-REM sleep, each of them exhibiting their electrophysiological peculiarities [141] with their associated centres and nervous circuits involved [142]. The intake of nutrients, another identified motivation, shows that the differences between hunger and thirst arise after breastfeeding, with specific variants of the motivation depending of certain nutrients, e.g., salt [143]. Taken together, the evidence confirms that any physiological motivation may display variations throughout development, as well as range of behaviours, as love does.

Different motivations can interfere with each other, or reinforce each other; for example, the relationship between sex and eating [55], or between sleep and food intake [144], have been shown. In addition, motivations and emotions act synergistically to favour survival [56,57,145–148]. Therefore, the variability in emotional experience increases the variability in the intensity of the motivations between different people. This is also the case in the experience of love.

Motivations and love, sometimes, may lead to an addictive process

We literally may be, as the song says, 'addicted to love.' In addition, *separation may be analogous to morphine withdrawal...* [149]. The same motivation can also produce the experience of differing intensities among different individuals of the same species [150], with regard to not only the organism's stage of development, age and gender, but also depending on many other factors, as previously commented, such as those experienced throughout childhood and adolescence [115–120]. In turn, this diversity has an effect on the differing disorders of motivated behaviours, notably in the case of addictions. Substance use disorders are characterized by disturbances in three major neuro-circuits: (i) basal ganglia-driven binge/intoxication stage (ii) extended amygdala-driven withdrawal/negative affect stage, and (iii) prefrontal cortex-driven preoccupation/anticipation stage [151]. Addictions can refer to both substances and non-pharmacological processes

The evolution of mammals was associated with a remarkable diversity of attachment mechanisms [...] that [...] constitutes the physiological basis of the higher level social affects, a powerful motivational force amounting to, in effect, a biologically based addiction to love [149]. The increase in the number of individuals in human social groups could affect brain development, perhaps promoting new currents of frontoparietal processing involved in the management of a progressive social complexity [152], as well as a number of associated disorders [153,154].

Presumably throughout the last 40,000 years (emergence and diffusion of arts), natural selection would have promoted the strengthening of love, and even before, for example, promoting help to loved ones [155,156]. In fact, in the last 6,000 years a strong positive selection of reward brain systems has been described [157]. These brain systems conform the main physical substrate of addictions [158,159], love [74,75,99,133,160–163] and attachment [97,164,165].

In many situations, love can be addictive, appearing as a powerful addiction towards another person from whom happiness is derived –following Dr. James Burkett and Dr. Larry Young, "*partner addiction*" [97]–. Pleasure in sex, unlike in love, can be obtained from others—regarding the similarities and differences between love and sexuality [77,166,167]. Among the signs of love identified by Dr. David M. Buss is "*the display of distress even in short separations*"— [168] in [169], emphasis added. Although the addictive nature of love could be in discussion [83,84,170–172], and not everyone experiences it throughout their lives, love may imply an addictive component *towards a specific person*—similarities between love and addictions in [76,97,99,102,173].

All people may not necessarily experience this manifestation of love, in the same way that the hunger experienced by populations suffering

from recurrent famines may not ever be experienced by the inhabitants of the more advanced countries. Addictions, attachment and love, share much of their brain substratum with motivations, especially those referred to as pleasure, impulse, and abstinence or mourning [171]. Of course, people experiencing the addictive variant of love, will show emotions and thoughts or behaviours that are exacerbated and out of control for a long time, perhaps for many years or even the rest of their lives, mainly if the relationship fails. However, even in the face of loss, the affected person may experience activation of the brain reward circuits and become addicted to enduring grief [171], associating even more love and addiction.

For Dr. Marc Lewis, addiction, in addition to not necessarily being considered as a disease, is “*an aspect or phase of personality development that leaves enduring footprints in neural tissue*” [172]. Addiction could be a natural situation in humans, perhaps affecting 47% of the population of the U.S. during a period of 12 months according to a meta-analysis with data from 83 studies (each study $n =$ at least 500 subjects) [173].

Given that addictions seem to resolve spontaneously with age in large numbers of people [172], their manifestation and development could evidence an underlying specific unattended or unfulfilled motivation, and it is proposed here that it is love. Similarly, the lack of love could be the main cause of alterations in other motivations (food intake—*anorexia, bulimia*—, sleep, sexuality), but it could also promote addictive behavioural processes [174] (bets, sports risk, the workaholic ...) or drugs abuse. *Love, attachment, addiction and motivation are closely related processes*, with common structures and molecules that are briefly detailed below.

There exist molecules that participate in the regulation of different motivations—as oxytocin does in food intake and love [165,175]—. In addition, an indirect action of gonadal steroids on the reward circuit through the medial preoptic area has recently been shown in rodents [176]. Besides to these and other neurochemicals arguments [151,177,178] for review; [179] for molecular mechanisms), there are also neuroanatomical reasons. This is because the brain structures associated with love [161,162,180] overlap with those associated with motivation and addiction, including the orbitofrontal cortex, insula, cingulate gyrus, ventral tegmental area and nucleus accumbens, [102,181,182]. Similar brain centres, molecules and circuits implied in love are involved in pleasurable pastimes and dedications, as in entrepreneurship [39] and in any other motivation.

One key question is how the environment conveys epigenetic influences on these circuits and the associated molecular mechanisms [151]. Thus, although food, love, some drugs, sports or video games, are not per se addictive, they may become addictive in some people due to epigenetic reasons that only now begin to be understood [183–185], which also depend on gender [186,187] and age [188,189]. The increase in the connections in the fronto-striatal circuits [182]—mainly between the insula and the nucleus accumbens [190]—may be involved in the compulsive behaviour in addiction, as observed in compulsive alcohol consumers.

In addition to the structures already briefly cited, several brain circuits should also be mentioned. Attachment has been especially related to specific brain networks, such as the *limbic system* (with the brain reward system), the *mirror neuron system* (premotor and inferior parietal cortex), the *default mode network* (mentalization system) and the *salience network* (anterior cingulate cortex and insula [138]). The cerebral substrate of attachment and love has been extensively studied and only some findings can be noted here.

The first study comparing the cerebral substrate of maternal and romantic love concluded that *human attachment [...] bonds individuals through the involvement of the reward circuitry* [162]. Midbrain dopamine-rich reward/motivation systems seem to be activated by early-stage romantic love. For instance, significant activations specific to the beloved have been found in the reward and motivation systems, particularly in the ventral tegmental area and the caudate; other areas associated with love are the mid-orbitofrontal cortex and cerebellum [76].

The activity of the brain reward circuit is essential to addictions [173] and motivations, and its proper functioning can be altered during development due to various factors such as drug use or maternal neglect [115–120,185]. Such is also the case of the inferior-frontal-occipital fascicle, which is affected by poor maternal love, which undermines the establishment of mother-child positive interactions [129]. This, in turn, affects the blossoming of child attachment, and, in adulthood, the deployment of maternal love in affected girls [129]. Thus, the maturation or myelination of this fascicle allows to associate infant attachment with maternal love.

In short, motivation, addictions, love and attachment, share a number of circuits, structures and molecules [97,99] that suggest a common motivational construct.³ In fact, there is a much closer correspondence between love and addiction, than that between any other motivation and addiction.

Physiological motivations (and love), once having appeared, are permanent

Neither sleep, which is apparently present at birth, nor the well-defined motivation for the consumption of food and water, which are found in mammals after weaning, nor sexual motivation, which is present after puberty, ever seem to disappear. However, they can be diminished in certain vital periods, for example, with the reduction of sexual hormones in the elderly or in the case of certain illnesses like anorexia or insomnia. This implies that love, once having come about, may also be permanent, in line with other physiological motivations.

And this is, without doubt, the most difficult aspect of love to understand due to the often short-lived experience of romantic coupling, which is in full accordance with the concept of emotion: It is now accepted that “*Emotions sometimes last as little as a few seconds, rarely more than an hour. Emotions come and go*” [1]. Forty years ago, it was also accepted that “*Emotion is a relatively short-term evaluative response*” [2]. The duration of love is a human transcendental question, even discussed as *eternal, or unanswered*, in the current psychological paradigm [191].

In fact, the high proportion of divorces and separations—over 50 per cent of marriages or more [192]—seems to reinforce the popular interpretation of love as an emotion by its apparently short-lived characteristics. However, couples are formed often without love, drawn together instead by sexual motivation and the intense emotions associated by extreme physical and mental proximity, as well as by the widespread scientific [32–38] and social [25] interpretation of love as an emotion. Really, not only our previous beliefs or conceptualizations about the facial expression of emotions in other people [193], but also religions [194] and substances [195] can affect our recognition of those emotions.

There exists proof of love being permanent and of the persistence of some of its cerebral processes: *Individuals in long-term romantic love showed patterns of neural activity similar to those in early-stage romantic love* [196]. Among other areas, *forebrain reward functions may be predictive for relationship stability...* [197]. Activity in the subgenual area and the superior frontal gyrus was associated with higher relationship happiness at 18-month follow-up [76]. While some researchers have

³ In this construct, in addition to various diseases of the motivations (anorexia, bulimia, insomnia), many other pathologies also associated with the alteration of frontostriatal homeostasis could be included, such as depression, attention deficit hyperactive disorder, drugs use, multiple sclerosis (executive control deficits), compulsivity, psychosis, apathy in Huntington and Alzheimer, obsessive-compulsive disorder, frontotemporal dementia, Internet gaming disorder, major depressive disorder, body dysmorphic disorder, excessive smartphone use in adolescence, chronic tinnitus, amyotrophic lateral sclerosis, executive functions in Parkinson, pediatric bipolar disorder, Gilles de la Tourette syndrome, anxiety in Williams syndrome, chronic pain, narcissism, executive dysfunction in temporal lobe epilepsy, Autism Spectrum Disorders (ASD), schizophrenia, and others (references are not included for reasons of space).

found that love may last for several years [198], others have found that it can last several decades: there have been respondents in long-term marriages (30 years or more) who report being *very intensely in love* [199,200].

Understanding love as an emotion or as a motivation might explain the diversity of interpretations about its duration. An excellent review and commentary on the terminological difficulties and on the duration of the relationship may be found in [138]: the existing work does show remarkable trends in the recruitment of neural regions and networks related to relationship length [76,197].

The neurobiological mechanisms responsible for love are known in depth, both in terms of circuits and in terms of molecules and structures involved, both central [31,75,77,97,99,133,161] and peripheral, as in the Polyvagal Theory [201]. Love's critical role in the evolution of *Homo sapiens* has also been suggested [202–205], even describing it as *an emergent property of the nervous system* [201], which has been recently reformulated: *Romantic love is the emergent property of the integration of the pair bond mechanisms* [31].⁴

Love being a physiological motivation, it may be considered as a permanent and unalterable mental function. However, the emotions and feelings associated with certain stages of its experience may vary as widely as peace, joy, sadness, jealousy, and grief. The fact that hunger or thirst does not arise does not mean that food intake is not a recognized motivation. Oxygen intake is also a motivation, whether the animal breathes several times per minute, or breathes several times every hour. Bees flap their wings in the hive only when it is necessary to refresh it. Food and water intake, breathing, reproduction, maintenance of temperature, sleep and love, are all differentiated motivations. Some motivations refer to homeostatic processes that require the replacement of materials and other motivations refer to bodily and brain homeostatic processes.

All of the above represents a transcendental change of the paradigm of human relationships that must additionally have clinical, social, cultural, and scientific consequences. Some possible examples are advanced in the following section.

Consequences of the recognition of love as a motivation

Clinical

The recognition of love as a motivation, like hunger, thirst, sleep or sex can lead to a better understanding and treatment of the pathologies associated with love, and encourage the recognition of these within the classifications of disorders, like *The Diagnostic and Statistical Manual of Mental Disorders* (DSM) [206], and the *International Classification of Diseases* (ICD) [207].

Thus, love would change from being considered an agreeable emotion associated with a pleasant sport (*lovemaking*) to becoming recognized for what it is in reality: an essential motivation for the survival of the individual and the species, just like eating, drinking and sex.

On the other hand, the disturbances and pathologies linked to love⁵ could be prevented and treated in primary care at the National Health

⁴ The consideration of love as an emergent property requires the reference of the taxonomic category to which the apomorphy would correspond (such as the production of milk in mammals, or the vertebral column in vertebrates). This would not be easy, given that in practically all the taxa of vertebrates and in many invertebrate, phenotypes of care, attachment, pair bonding, and matching are found –review in [180]–. On the other hand, considering love as a physiological motivation forces us to assume its evolutionary unfolding in taxonomic categories prior to the extant *Homo sapiens*. Therefore, the extreme importance of love in Hominid evolution –mainly in genus *Homo*– is here emphasized.

⁵ As the proposed *love withdrawal syndrome* (analogous to the *opiate withdrawal syndrome*), also with other denominations, for example, *Lovesickness* [208], which could be one of the causes of the murder of women by their partners and ex-partners when the woman wants to end the relationship [209].

Services, just like those related to nourishment, sleep or sexuality. As with other motivations (next paragraphs), love events (e.g., sentimental unions and breakdowns) may require professional attention and perhaps treatment, and some associated pathologies will appear in the *International Classification of Diseases*, wherein they currently do not.

ICD-10⁶ classifies “*Behavioural syndromes associated with physiological disturbances and physical factors*” through categories F50 to F59. These recognized physiological, medical, clinical, physical or mental disorders are motivational disorders. Specifically, ICD-10 includes “*Eating disorders*” (F50), “*Nonorganic sleep disorders*” (F51), and “*Sexual dysfunction, not caused by organic disorder or disease*” (F52). Indeed, it includes several sex-related disorders, as “*Gender identity disorders*” (F64), “*Disorders of sexual preference*” (F65) or “*Psychological and behavioural disorders associated with sexual development and orientation*” (F66).

It is still surprising that the ICD-10 does not include the word “*love*” or that it does not constitute a category. Love, one of the 500 most commonly used words in the English language, only appears three times in the ICD-10; as behaviour in F52.2, in treating problems of ejaculation when *lovemaking* in F52.4, and in relation to the criteria of *Narcissistic personality disorder*—preoccupied with fantasies of unlimited success, power, brilliance, beauty or ideal *love*—in Appendix 1 of ICD-10. Finally, the ICD-10 also mentions a type of love-related anxiety in certain tribes (Bantu, Zulu and affiliated groups). Although *lovesickness* can seriously affect the quality of life, it is not currently considered an official disease [208].

In this way, the circle that considers love as an emotion associated with sexuality is closed. There is a consensus about the erroneous acceptance of love as an emotion [25,32–36]. For this reason, it will take a long time to accept the inclusion of love in the category of motivations. However, such an inclusion would have an immediate effect on the health and wellbeing of the population.

The recognition of *love* as a physiological motivation similar to *sex*, *eating* or *sleep* may result in a specific ICD category, perhaps replacing any of the existing ICD categories related to sexual disorders. For example, it is suggested here that the erroneous interpretation of love as an emotion is responsible for the existence of disorders such as *anorgasmia*, which might be non-existent if it were love rather than only sex what unites human couples. In fact, professionals in psychology and psychiatry currently deal with the difficulty of a significant number of women to obtain orgasms in their sexual relations by considering factors such as personality traits, medical records, and abuse reports *that do not predict orgasms in women*, according to extensive research examining almost 1500 pairs of twins⁷ [212]. The insula, involved in love and addiction experience, has been found associated with female orgasm [213].

Functional alterations in the reward and emotion regulation network, and the reward dopamine brain system, may constitute the neurophysiological basis of romantic love as a behavioural addiction

⁶ The *World Health Organization* (WHO) has published its new *International Classification of Diseases* (ICD-11) on June 18, 2018 [210,211]. ICD-11 will be presented at the *World Health Assembly* in May 2019 and will come into effect on January 1, 2022. For didactic reasons, this article refers to the 10th version best known to psychologists and physicians.

⁷ The aforementioned research sought the cause of a major problem in the lives of many women, *anorgasmia*, to the point that only a few years before, it merited an extensive international study involving more than 200 experts from 60 countries gathered in 17 committees. This panel of experts established the limited efficacy of current available treatments (both psychological, such as Behavioral Cognitive Therapy, and pharmacological, such as bupropion, sildenafil, and other drugs), and concluded that it affects a quarter of women [215]. The cause of the problem perhaps could be better understood from a different social, cultural and scientific interpretation of both love and sex, as well as from a better understanding of brain circuits involved in the interaction between these two physiological motivations, love and sexuality.

[214]. Following this, it is possible to fall into an addictive spiral with dependence and withdrawal syndrome. However, such a similarity between *Romantic Love vs. Drug Addiction May Inspire a New Treatment for Addiction* [214], given that *the Fields That Investigate Romance and Substance Abuse Can Inform Each Other* [99]. Thus, despite the preconception that love feelings are uncontrollable, regulation of love feelings using reappraisal, and perhaps other strategies, can be feasible [80]. It would be clearly advantageous if we could regulate love feelings at will, so that we could up-regulate them when they are weaker than desired, and down-regulate them when they are stronger than desired [80]. Love can also influence the evolution of a multitude of other psychological and organic pathologies, as for example in increasing analgesia [216] or attenuating the symptomatology of tobacco abstinence [217].

With the normalization of love as a motivational state, people would get used to consulting with health professionals regarding their stages in love. Love may then be measured routinely by neuroimaging, genetic, chemical or behavioural techniques [218]. As a result of this, cases of risk of violence and simple individual differences (for example, poor resilience in the face of a break-up) may be recognized and promptly treated by health professionals (psychologists and physicians). These differences, and particularly the generalized consideration of love as an emotion, may also be responsible for the scourge of femicide [209]. Such differences may someday be detected and treated without their current terrible consequences.

Social

There is a generalized confusion between sex, sexual behaviour, gender, and love. Even religions that insist on the importance of love in their rites and scriptures keep women away from important positions. Throughout history, controlling access to sex via the most diverse ways has been the main means to control the population by political and religious groups. Many countries and religions accommodate legislation and rules on physiological motivations, namely, what type of sex is allowed—as recently in India [219]—, what type of food is allowed, and so forth.

The confusion of love with sexuality has been a mistake in the recent history of humanity, but with a clear beneficiary: men. Even today, those in power (mostly men) are responsible for the confusion between love and sexuality; they accomplish this by managing to control sexuality, which is one of the main sources of power in the majority of animal species with social structure. Therefore, *when we talk about romantic love we mean love corrupted by its power context—the sex class system—into a diseased form of love that then in turn reinforces this sex class system* [220].

Religions and societies have tried via institutionalized marriage to create a false and forced state of love in unions mainly motivated by sexual interest, but also by the demands generated by the imbalance of homeostasis, which defines love as a physiological drive (which behaviourally and mentally is translated as affection craving, company, caresses, support, wellbeing, pamper, happiness, among others). This phenomenon has made it difficult to understand the meaning of love and its differences from sexuality [26,77], two well-differentiated motivations.

Accordingly, in one of the most influential books of the twentieth century by one of the most influential thinkers of her generation, the *Second Sex* by Simone de Beauvoir,⁸ the word *love* appears almost 1400 times. She wrote, *“The word ‘love’ has not at all the same meaning for both sexes, and this is a source of the serious misunderstandings that separate them. Byron rightly said that love is merely an occupation in the life of the*

man, while it is life itself for the woman. The same idea is expressed by Nietzsche” [221]. The acceptance of both sex and love as two different physiological motivations will improve the understanding of mind/behaviour differences between women and men. This will allow a better understanding of the meaning of the production of one gamete per month in women, compared to the production of more than hundred million gametes per day in men.

Confusing sex and love has been proposed to have serious consequences on the health of the population [204,205]) and, particularly in the United States, could be a cause for the growing demand of psychoactive substances and the increasing suicide rate. As Dr. Monica H. Swahn states, *it is not clear what exactly drives the demand for the psychoactive substances and what has driven the increase in suicides. But I think it’s worth speculating whether a perceived low quality of life for many Americans, marked by high stress and low levels of happiness, is contributing. Americans stand out from people in other countries, with respect to their focus on individualism* [222].

Individualism, introversion, social anhedonia, and loneliness [223] affect physical proximity between different people, and are personality traits related to fear circuits—dysfunctional social needs promote psychopathology [224,225]: The intimate circle [0–45 cm] corresponds to the distance closely surrounding a person’s body [226], wherein one feels comfortable interacting with intimate others (in [227]). Lonelier people exhibit elevated functional connectivity within the cingulo-opercular network, involved in the maintenance of tonic alertness [228]; in turn, personal space violations within proximal interpersonal distance, preferentially activate the bilateral amygdala [229], part of fear neurocircuitry [230] and which is *deactivated in love* [162]. As expressed by Drs. John Terrance Cacioppo and Stephanie Cacioppo, and their colleagues, loneliness is a risk factor for poor physical and mental health [223].

The clear opposite of individualism is love, which is broadly recognized as the main cause of happiness—love may thus be understood as a *subcategory of happiness* [86]—, given that married/cohabiting life seems to yield greater happiness [112,135,231] whenever the relationship is based on gender equality. It is appropriate to recall here that objective 5 of the 17 objectives proposed by the United Nations to *transform the world* with the horizon in 2030 is *achieving gender equality and empowering all women and girls* [232]. Recognizing love as a motivation, different from sexual motivation, would profoundly affect interpersonal and social relationships.

Cultural

The recent past and historical events of humanity may be easily reinterpreted with another appreciation of love, although Charles Darwin himself wrote “[...] *The emotion of love* [...]” [233]. Likewise, the consideration of love as a motivation explains essential aspects of human evolution, especially in the last million years, with the progressive extension of childhood⁹ [105]. Although other authors place the origin of affiliative behaviour, promoting the adoption of social monogamy, even further behind, preceding or accompanying bipedality [234], genetic research shows that the emergence of civilization (in the European population during the past 6000 years) was characterized by an intense selection on brain’s dopamine reward circuitry [157], associated with motivated behaviours, addiction and love [173,214]. In addition, the argument of love as crucial factor in human ontogeny [115–119] could be used as indirect evidence (as proposed by evolutionist embryologist Ernst Haeckel) in support of *love as having an important role in human phylogeny*.

The gradual establishment of love in this period is essential to

⁸ In 1929, Simone de Beauvoir became the youngest person ever to obtain the agrégation in philosophy at the Sorbonne, placing second to Jean-Paul Sartre [221].

⁹ Although “*considerable variation within and among fossil and extant species suggests that taxonomic interpretations of dental development in early hominins should be made with caution*” [235].

explain many important evolutionary issues, such as the following:

- a) the absolute helplessness of human offspring, that would cause his disappearance without a strong maternal motivation of love;
- b) The appearance of new evolutionary stages, such as childhood and adolescence, which are non-existent or brief in other primates, associated with the human slow brain development [236]. It has been suggested that younger chimpanzees require direct maternal provisioning to survive until age 3 [237]. Adolescence is a critical period of addiction vulnerability [238], and love addiction is likely manifested by the time one reaches adolescence [173];
- c) The duration of childhood, which has been identified in the fossil records as progressively increasing over the last million years [105], and enabled only with the progressive extension of maternal love, with current weaning earlier than in other large primates [237], or other hominids [239];
- d) The disappearance of body hair prevents the materialization of the baby's grasping reflex, causing the mother must transport the baby. This should promote maternal sustained attention, short-term memory and abundant stimuli to prefrontal cognitive development ... It has been suggested that this is an essential factor in humanization [240]; in turn, it could have promoted the group's sedentary life and the development of the social brain, further allowing the Darwinian selection of genes involved in skin lightening [241];
- e) Bare skin promoted intimate physical contact [242] i.e., caresses, between the mother and the baby, surely driven by the need for thermoregulation, provided that the conservation of energy through social thermoregulation occurs throughout the development and in later life, and both have consequences for the development of physiological mechanisms that support attachment [243] –it includes detailed study on the relationships between attachment, brown adipose tissue, oxytocin and social behaviour–;
- f) Other consequences could be related to secondary sexual characteristics such as female breast growth and breasts' role in intimate relationships [244], and the concealment of the female genitalia contrary to what happens in bonobos (*Pan paniscus*) or chimpanzees (*Pan troglodytes*) [245]; then, the significance of the creation of love becomes phenotypically apparent in the evolutionary line of human being, differentiating it from sexuality;
- g) The prolonged human female longevity after menopause, unlike the chimpanzee, where the female dies shortly after reaching menopause, both in wild life [246] and in captivity [247]. *Love could be associated with human longevity*: Really, *love promotes health* [178,231], given that loneliness has an adverse effect —perhaps through cortisol levels [248]— on health and well-being [249]. On the contrary, married/cohabiting life seems to give greater happiness [112,135], and *Happy Older People Live Longer* [250]. In fact, grandmaternal love similarly involves different regions of the prefrontal cortex, as does maternal and romantic love [251];
- h) Characteristic human behaviours, such as the proclivity towards rewarding and addictive substances and behaviours. These behaviours have been associated with an intense positive selection of the cerebral reward systems related not only to motivation and love in *Homo sapiens* [157], but also to highly prevalent human diseases such as depression. Depression seems to be one of the main consequences of loneliness [252]. Circuits and structures associated with love and addiction [167] are also involved in depression, namely, the *nucleus accumbens* [253], but also certain molecules, such as opioids [254] or cannabinoids [255]. The persistence of behaviours and emotions seems to depend on the prefrontal cortex maturation and its functional circuits [256–258], as well as on other areas of the forebrain, septum, fornix, posterior cingulate [196,259–262] and others, also involved in love. They are also involved in *Obsessive Compulsive Disorder—OCD* [263,264]—suggesting that addictions, depression, OCD and love [163] could also be related within a motivational construct dependent on fronto-

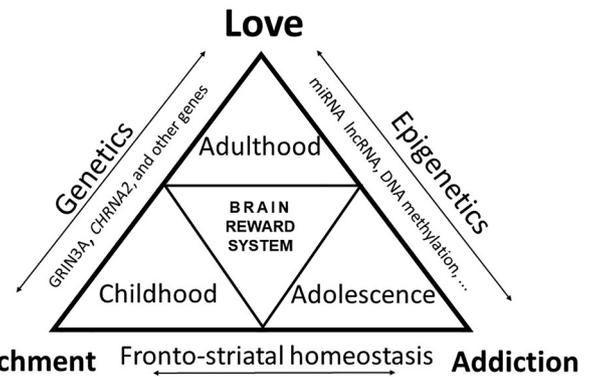


Fig. 1. Motivational construct in the human brain. This Figure provides clues about the origin in the brain reward system (and love) of many peculiarities and motivational disorders affecting human being health. The *brain reward system* is central to all motivations, intake of nutrients [268], sexuality [269] and even sleep [270–275]. This motivational construct relies on genetic and epigenetic factors, as well as on frontostriatal homeostasis. *Only for didactic reasons these three factors are distributed on the three sides of the triangle.* The phenotype prone to addiction can be passed on to the next generation, and a suggested mechanism may be seen in [308], published when this article was in the editorial process. Therefore, the origin and transmission of the motivation of love in human species may begin to be explained, based on the brain processes responsible for attachment and addiction, which correspond mainly to human childhood and adolescence. In the same way, adult love (romantic love) corresponds to adulthood due to the prolongation of the maturation/myelination of human fronto-striatal connections. These are promoted by human *FOXP2* gene, which is also involved in human verbal language, and its down-regulation and overexpression, in cancer [309].

striatal homeostasis and dopaminergic, oxytocinergic and peptidergic afferents [265,266]. Attachment and long-term romantic love share a similar brain activity pattern in dopamine-rich reward systems [196]. Along with evidence from the clinic [267], altogether supporting the motivational construct summarized in Fig. 1.

- i) Love could have originated at the same time that fidelity emerged as a factor of reproductive success in hominids: the faithful parents, lovers of their partner and their offspring, transmitted their appropriate love genes, unlike the selfish parents who disowned their progressively helpless children, then these dying [276]. Human fidelity is here proposed to have arisen in women a million years ago in the context of the maternal relationship [205], caused by progressively longer childhood [105], although other authors place the beginning of monogamy even before, preceding or accompanying bipedality [234]. Moreover, fidelity must have extended rapidly as a characteristic of most males, according to a computer simulation exercise [276];
- j) The evidence found of compassionate love for strangers in fossils with wounds and malformations, which is incompatible with life without third-party care [155,156]. This care for the handicapped must firstly have arisen in the mother-child/couple relationship, and been motivated by love, due to the neurobiological link between compassion and love [277] and because of love changes the functional connectivity in the empathy/*social cognition network* [278].
- k) The same human verbal language, which is briefly detailed below.

In this regard, Dr. Dean Falk [279] and Dr. Susan Sheridan [280] have already proposed that language emerged in human evolution in the mother-child interaction. Love was likely the only responsible force in the Hominid taxon capable not only of maintaining the primitive protolanguage over one million years in the maternal-infant interaction, but also of promoting its development. This, beyond strictly genetic factors, such as the positive selection of mutations in the *FOXP2* gene, which has been demonstrated in European populations [281], but not supported by data obtained from larger samples [282].

Regarding the unknown language capabilities of other hominids, the recent finding of the production of “vowels-like” and “consonants-like” calls in primates should be mentioned, with speech-like rhythm exhibited by *Pongo pygmaeus* orangutans [283]. Similarly, expressive orofacial movements—*lipsmacks*—studied in the macaque monkey (and perhaps, *kisses*, and other) could have been a putative evolutionary precursor to human speech [284], in both phylogeny and ontogeny.

About 40,000 years ago, the generalized extension of love to the relationship between the sexes (and perhaps male fidelity) could be the driving force responsible for the widespread appearance of the arts and for the accelerated evolution of primitive linguistic families [285]. The extension of love within societies may have greatly influenced kinship relations, genes flow, and the spread of language. This is supported by a recent study, which comprised inhabitants from about 25 villages from two Indonesian islands with different rules of kinship. Findings indicated that the dynamic interaction between language and kinship was fundamental to the structure of social life [286].

The oldest art samples show an amazing temporal coincidence: the first sculptures 35,000 years ago [287], art painting, that is, parietal rock art in Europe—Spain, 40,800 y.a. [288]—and Indonesia—Sulawesi, 39,900 y.a. [289]—, and also music, namely the first instruments in Germany, 40,000 y.a. [290–292]. The arts in general, and music in particular, constitute a communication system capable of generating various and extreme emotions [11]. *Music is a universal language that may have evolved to help humans [...] communicate and understand one another* [292]. One of the most recognized social functions of music is *communicating love and calm babies*—from a study where people from 60 countries listened to songs of 86 small-scale societies [293]. Love, language and art are closely linked, as summarized in Fig. 2.

Scientific

Considering love as a physiological motivation, such as food intake, sleep or sexuality, would also help to highlight the numerous findings regarding love that can be found in scientific research.

For example, recent work shows that the use of the hormonal contraceptive pill (HC) has a devastating effect on the experience of affection triggered by intranasal oxytocin (OXT) in women when they see their partner’s face [294]. Oxytocin has been used frequently to study interpersonal relationships, given its known mechanisms of action and its ease of application [295]. A study showed that OXT effects did not significantly differ between freely cycling women and men, but OXT-induced augmentation of partner-specific responses in the nucleus accumbens was significantly stronger in men than in women who used HC

[294,296]. Indeed, the OXT-induced activity increase was significantly stronger in freely cycling women than in women using HC both in the accumbens and in the ventral tegmental area [294], which are brain areas responsible for the pleasant experience (Brain Reward System in Fig. 1) associated with the motivations.

The authors of this suggestive study only mention the word love to describe, in the Method section, “*The subjects reported to be passionately in love ...*” [294]. However, this work suggests devastating effects of the use of the contraceptive pills in the love relationships, specifically, in the love experience (emotions, cognitive processes, feelings, behaviors, associated with this motivation) of the woman using the pill when she sees her partner’s face. These actions presumably could also imply diverse actions of contraceptive pills on a number of brain areas [297], some of which, such as the orbitofrontal or cingulate cortex [298], are also associated with love [75,99,161,162].

If love were considered as a motivation, the results mentioned above, although preliminary, perhaps would justify further investigation by the health authorities and the pharmaceutical companies themselves that produce hormonal contraceptives: these pills could contribute to divorces and break-ups, further strengthening the belief in the emotional and ephemeral nature of love. However, it seems less important if love is considered as a temporary emotion than if it were considered a permanent motivation.

On the contrary, certain treatments could be considered opportune for the maintenance of this motivation when the affected persons detected highs and lows in their love relationships and wanted to preserve them or not [80] in a similar way to the use of somniferous drugs in periods of insomnia. This would of course involve ethical and legal considerations [84,299].

Finally, the acceptance of love as a physiological motivation might illuminate the answer to Dr. Ruth Feldman’s last question in her seminal article of 2017: *Can the neurobiology of attachment provide a unique entry point for the integration of science with the humanities, arts, ethics, and clinical wisdom?* [218].

Conclusions

Culture makes the current human being live a fantasy of love as only an emotion that does not correspond to the reality of love created by evolution. Some of the reasons that demonstrate the reality of love as a motivation have been summarized above. The present article has not attempted to deny love’s intense emotional components, nor its interpretation as the deepest human feeling.

Any motivation can be accompanied, or enriched, with a vast range of emotions and feelings, and also guide the will and affect the reason. However, they lack the extreme intensity and diversity qualities of love, acknowledged by love’s widely accepted typologies.

Understanding love as motivation does not imply that it only has a physiological explanation, because “*although physiological analysis can help us understand [...] motivated states, physiological explanations alone are inadequate*” [42].

A final point pertains how regarding love as a motivation could have not only enormous social and cultural consequences, but also scientific and clinical implications on human physical and mental health. A myriad of physical and mental disorders have been linked to lack of love in ontogeny (defined as abuse or neglect), including a higher prevalence of various factors epidemiologically associated with cancer: *Antecedents for adult cancer may be rooted in childhood experiences* [300]. From this it may follow that, at the other end of our lives, the loss of the beloved could trigger the death of the survivor, as in the Takotsubo cardiomyopathy (or broken heart syndrome), which has been associated with stress or the loss of a loved one [301,302]. Takotsubo syndrome may be related to changes in functional connectivity in those brain circuits [303,304] that have been found mainly affected by love [278]. Certainly, Takotsubo cardiomyopathy may also be caused by drug withdrawal, for example to opiates [305,306] or alcohol [307],

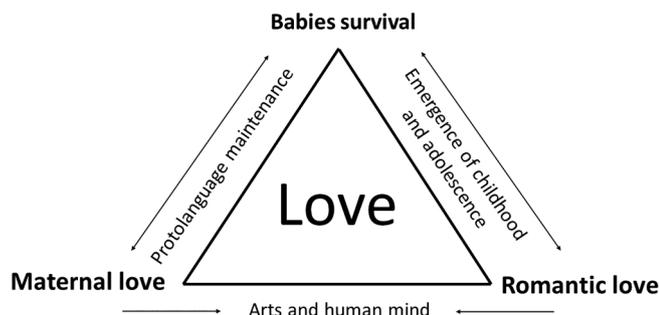


Fig. 2. Main consequences of love in hominid evolution. Love is the motivation mainly responsible for the evolution of the human mind, language and art. This figure explains the need of childhood and adolescence in human ontogeny for the gradual construction of love, which accompanies each human life throughout life. It could also serve as an explanatory framework/scaffolding of human phylogeny, assuming the gradual increase of childhood (and maternal love) in approximately the last million years and the sudden rise of all the arts and linguistic families about 40,000 years ago.

which would more strongly associate love with motivation and addiction.

Furthermore, the consequences of the acceptance of love as a motivation would also influence many other realms, especially in the establishment, the course, and the future of sentimental relationships. Above all, it may allow people to better understand love and to differentiate it from sexuality, which will have immediate consequences for well-being and happiness.

In short, this paper proposes that love is a biological motivation similar to nourishment, sleep and sexuality. It also points out the need to integrate love with the rest of the motivations not only in the basic scientific field, but also in the clinical and cultural field. The impact could be extraordinary.

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Conflicts of interest

The author declares no conflict of interest.

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