Jan Rostowski
University of Finance and Management in Warsaw
Faculty of Psychology

Bioneuropsychology of Love –
Selected Aspects

Abstract
I would like selectively, on the base of review the neuropsychological literature from the last decade, to present the following neuronal circuits and important, concomitant processes related, directly or indirectly, to the phenomenon of love, as:

A proposition of definition romantic love and commons signs of behavior of beloved person in bioneuropsychological perspective. The impact of the genetic similarity on the processes of interpersonal attraction and falling in love; and also the role of the evolutionary strategies concerning mate selection and choice of partner for long-term or short-term interpersonal relationships as marriage and have children to transmit the their genes for next generations. In particular, the specific role of activity the neuronal structures, processes and concomitant functions, and also changes connected with neurohormonal system and its consequences for an individual of possibility falling in love. The constitutive elements of romantic love as: romantic attraction and also attachment. The role of the “mirror neurons systems” within the processes and states, especially such as: self-regulation, reappraisal, imitation, reading in mind, et al., of the vital importance non only for the falling in love, but also more for maintenance the love between partners of close interpersonal relationships, as marriage, for their life. In conclusion, I would like to stress the fundamental importance of the social nuropsychology for more adequate understanding non only various aspects of love within individual’ diary behavior but also for her or his happiness and quality of life.
Introduction

The main purpose of this article is an attempt to reveal that the essence of love, despite the abundance of the recognized, recorded and even immortalized expressions in the literature, from philosophy, theology, essays, treatises, above all poetry, various forms of art, and to scientific behavioral researches, has nevertheless remained nearly unknown regarding its essence and genuine origin. Here, however it is worth to mention some propositions of great philosophers concerning the love understanding. According to Socrates love is any equivalent of beauty and to Plato erotic or romantic love is a version love of wisdom, and a reason for this love is any universal beauty as such, which is particularly perceived by a person. Moreover Plato more expressively explain his conception of love referencing to classic myth about humans beings as double creatures, cleft in half by Zeus and left to wander the earth looking for their other halves, and till when they meet each other they may be happy and (be)loved because they fit together, and in this way they became enable to share each other ideas, values and aspirations (Solomon, 2002). (It might to add, that this Plato’s conception of love, in some extend, has a reference to the contemporary theory of genetic similarity (about what will be discussed below). Very important and interesting is Aristotle’s conception of three types of friendship in his Nicomachean Ethics, that are related to love. The third out of those more strictly concerns the love, which may be defined as friendship mutually inspiring one another. Because the essence of love is mutually inspiring one another the true love is neither selfish neither selfless, nevertheless it is, in one sense, a matter of both beloved partners benefit. For example, E. Kant treated love in dismissed way as a sentiment as merely pathological and juxtaposed it practical love based on reasons. In turn, A. Schopenhauer thought that love is the irrational striving of the will to live; (it might discern that this conception of love has any reference to contemporary evolutionary view of love in any sense as a process and means of propagation of own genes of both beloved partners through their offspring for next generations). However, J.-P. Sartre
argued that love is just another stratagem for manipulating the other. In general, one can say, that most contemporary philosophers or thinkers avoid for conceptual and holistic consideration of love, preferring analytic and episodic descriptions of experiences of love by particular individuals (Solomon, 2002; Misiak, Sexton, 1965).

Yet, in the period mainly of the last fifty years problem of love became the object of undertaken oft psychological studies in framework of the different conceptual approaches and strategies of research, however mainly within personality and social psychology. Thus some psychologists also have tried create conceptions concerning love, but rather in the phenomenological and descriptive or narrative perspectives on basis of subjective experiences’ partners in love or falling in love, founded on obtained results with use of surveys and subjective self-reported questionnaire research’ methods and also processes of abstraction; (yet without any approach to automatic, non-conscious processes underlying experiences of love). In this and similar way were formed different conceptions and approaches to treat phenomenon of love. Only for example may to point at: J. Lee’ typology of six love styles (1977): storge, ludus, eros and mania, pragma, agape; or R. Sternberg “the triangular theory of love”: intimacy, commitment, passion (1986) and then “the love stories”(1995), also three out of twenty four the most important love stories, i.e. love as science, love as art, love of war (1996); on similar ground was yielded a taxonomy of five different “ways” of experiencing partnership love by J. Hinde (1997): intuitive love, companionate love, secure love, traditional love, committed love; and others (Watts, Stenner, 2005; Duffy, 2009; Jacobs, 1992; Rostowski, 1987).

Nevertheless, what should expressively be emphasized, in all nearly previous, different, but the known in history the views of love, and also these above, only in selective manner, presented conceptions of love, are omitted the fundamental resource/roots of love connected with the biological, and more precisely the genetic, evolutionary and finally the neurological structure, but exclusively concerning the human brain. However the above mentioned issues concerning essentially the romantic love, con-
sidered yet in the modular approach, i.e. with many different its aspects and components, pose precisely the main object of this debate.

It is well known fact, that there are many various and sometimes contradictory definitions and similarly also, as well as, conceptions of love. In this theoretical and factual context one may think it proper to restricting just to the definition or rather description of love corresponding with the main content of the article. Yet, to begin, it should to emphasize, that really there are still very little definitions of love according to the bioneuropsychological approach. In principle, because of the very short time of the ongoing studies on love in this perspective.

However, so from this scientific point of view, love, especially romantic love can be defined as “an integrated neurobiochemical process which aims to promote not only reproduction, but also proximity, sense of safety, joy and to reduce feelings of stress or anxiety” (Marazziti, 2005, 331). In similar way love may be described, namely that: “Intensive romantic love takes place within a modular framework that can be differently activated according to potential fluctuations of love… [or] Intense romantic love can be defined as a complex state involving cognitive, chemical and goal directed components, [and more descriptively] … intensive romantic love mainly activated brain regions with a high concentration of receptors for dopamine and a related agents, norepinephrine, i.e. the chemical messengers closely tied to states of euphoria, craving addiction, heightened attention or sleeplessness” (Bianchi-Domicheli et al., 2006, 91–92; Aron et al., 2005; Ortigue et al., 2007a). Moreover, it needs to stress that intense romantic love probably is primarily a motivation system, and a specific constellation or range of emotions rather than a specific emotion, because intense ongoing love recruits subcortico-cortical pathways associated essentially with love, mediating reward, emotion and motivation systems. It occurs so among others therefore, because dopaminergic, especially reward pathways contribute to the general arousal principal component of romantic love and in general motivation system. In any sense so thought love may be considered as if any form of drive, but this “drive of love” is distinct from the sex drive, mainly therefore because this drive of love
changes its form across time of life and first of all it is served in principle
by different neural circuits than the sex drive, and most often can occur
independently, although some neural circuits of both these drives overlap;
in similar neuronal way also differs love from maternal love and friendship
(Ortigue et al., 2007a; Aron et al., 2005; Fisher et al., 2005; Diamond,
2003; Beauregard et al., 2009). And moreover, romantic love does not
simply mean loving someone – it also means being in love. In general love
may be conceived as a complex, multilevel phenomenon encompassing
a large set of behaviors, attitudes and feelings (Berscheid, Meyers, 1996;
Troy, 2005; Ben-Ari et al., 2006).

Selected Signs of Love

Passing over different more subjective ways of experiencing love, in
general and universal approach, it appears that above all people involved
in intense, passionate romantic love or intimate relationships most often
manifest, for example, such signs as active strive for the happiness of the
loved person. Moreover, they often experience an inability to feel romantic
love for more than one person at a time, and they display a tendency to
think about the loved person for most time of their waking hours during
the day. Intense and especially, but not only, romantic love is reported
to have very specific effects such as euphoria, loss of appetite, trembling,
a pounding heart, accelerated breathing, hyperactivity, delay in the onset
of fatigue, decreased need for sleep, reduction of stress as well as a poss-
ibility of health improvement, and so on (Ortigue et al., 2007a; Bianchi-
-Demicheli et al., 2006; Esch, Stefano, 2005; Gonzaga et al., 2001; Bart-
tels, Zeki, 2000; Diamond, 2004). (Others symptoms or signs of roman-
tic love will be occasionally discussed below). But for the more adequate
and essential understanding of love, it is need to take together different
symptoms rather as a syndrome of love than to consider only a particular,
although, may be, more expressive sign.
The Preliminary Assumptions of Bioneuropsychological Approach

Even if only the above mentioned universal signs of love occur, the question arises: why do they occur in such a way, and above all: why do people fall in love and need the love of somebody else in their life. In order to answer this question it is necessary to take into account the fundamental factors or conditions influencing human social behavior, i.e. mainly genetic factors, evolutionary processes, as well as neuronal structures and functions or, to be more strict, the scientific results of the neuroscience and more strictly the social neuropsychology.

In the beginning it should be stressed that the aim of the examination of the bioneuropsychological basis of love does not consist only in taking into account detailed and specific genetic, evolutionary and neuropsychological processes, mechanisms or regularities regarding the individual in love, but rather in the modular, yet selective, characteristic connections or relations between genetic, evolutionary and neuropsychological processes or mechanisms, as well as also experiences and behaviors of adult individuals being in love within close, interpersonal relationships. Moreover, in principle, the object of the examination of these three factors is to indicate that their appropriate constellation may be a fundamental resource to occurrence different predispositions, preferences, tendencies, as well as inclinations and susceptibilities to display definite forms of activities and behaviors (not always correct and favorable), which are also related to love within close interpersonal relationships (Harmon-Jones, Winkielman, 2007; Norris, Cacioppo, 2007; Zeki, 2007; Hinde, 1993).

It is worth to add and stress, that social neuropsychology underlines the importance of cognition and understanding the way in which body and brain functions influence in social processes and behavior, and reversely, the way in which social processes and behaviors influence in body and brain functions (Harmon-Jones, Winkielman, 2007; Cacioppo et al., 2002; Hinde, 1993).
Genetic-evolutionary Correlate of Love

When it comes to behavior genetics, aside from the details, it needs to highlight that people’s genetic structure, or more precisely the genome-genotype influences on activity and behavior more often indirectly through the nervous system, in cooperation with the environment (Carver, Scheier, 2000; Larsen, Buss, 2002; Strelau, 2006).

Such regularity may be helpful in providing a general explanation of the differentials of attitudes towards love, and also toward preferred different styles or types of love, for example according, above mentioned, J. Lee’s typology of six love styles or Sternberg’s “the triangular theory of love” and then “the theory of love stories”, and especially towards the beloved person, as well as the susceptibility to falling in love, and becoming infatuated at the first sight. It appears that the dynamics of relationships of partners in love are in subordination to expectations and purposes genetically programmed within both partners, which may be sometimes a little different, yet may be creating a potential threat for a relationship initiated by love or infatuation (Fletcher, 2002, Fletcher et al., 2006; Hatfield, Rapson, 2006; Simpson, Tran, 2006; Duffy, 2009).

In this context it need to highlight the importance of the genetic similarity between partners in close interpersonal relationships, especially with a perspective of their falling in love or becoming infatuated. In light of the results of studies conducted among others by Rushton, it appears that partners within the well selected, happy, harmoniously functioning close relationships, such as marriage, are well matched on the basis of genetic similarity. This similarity is measured by many also genetically programmed indicators or biomarkers, e.g. blood group, similar smell of sweat, defined type of figure, physical attraction, physiognomy, and so on, as well as many others somatic, physiological and also many psychological factors. Very important role play, when it comes to psychological aspects of this similarity or matching, first of all, attitudes, values, beliefs, expectations and also some traits of personality. All these above mentioned factors and many others, which are not necessarily consciously recorded,
most often unconsciously perceived and subconsciously processed, performed and evaluated (probably above forty). What is more important, a constellation or defined modular pattern of cognitive factors and neural circuits associated with them, is also subconsciously created on the basis of these factors. Thus, to be more specific, this pattern formed on the basis of the perceived and experienced similarities in other individual, create a sense of propinquity, bond, need to be together and above all feeling of love. Therefore the happy and being in love marriages are characterized by a larger scope of similarities in comparison to unhappy marriages. The same rule (principle) of genetic similarity also concerns the selection of partners for close relationships and also others relations as friends, colleagues, acquaintances, and also to feel affection and sympathetic altruism even (from) for unknown people, or people met by a chance encounter, yet who are just genetically similar. It should be stressed that such possibility or opportunity may play the key role in cases of falling or being in love and in particular often of infatuation (Rushton, 1989; Larsen, Buss, 2002; Carver, Scheier, 2000; Fletcher, 2002; Fletcher et al., 2006; Sundie et al., 2006).

It still need to add that the fundamental and universal emotions-feelings, such as love, joy, sadness, fear, surprise, disgust, anger – also have genetic roots. The individual's tendency to display diversification regarding the frequency and intensity of the occurrence and expression of these feelings is also genetically conditioned. Similarly, the same genetic mechanism also applies to the susceptibility, e.g., to the positive or negative affective, optimism or pessimism, happiness or sadness, love or hate, and so on. One should strongly to emphasize, that the role of these regularities is fundamental for the understanding of the diversification, changeability and sometimes opposition or contrast of experienced emotions, feelings especially at the exact initial period of falling in love, and first of all infatuation (Carver, Scheier, 2000; McAdams, 2001; Rostowski, 2008; Newman, 1997).

In the field of investigation over the conditions of the occurrence of love the pivotal role is played by the universal, so called, “genetic needs”,

despite occurrence of significant cultural differences. First, the tendency to select partners with defined traits, qualities for close relationships, but diversified regarding sex, which plays an important role within marriage or others interpersonal relationship based on the love. Second, the genetic need to require of experience and displaying the feeling of love, Third, the genetic need to have offspring in order to transmit their genes to next generations. Fourth, above all the genetic need to survive and to guarantee life for their children. First of all, these genetic needs (but non only), create the ground for the formation of the structure of marriage as a relationship between two persons of the opposite sex, based on love and monogamy, becoming successively the social institution helpful to meet all above mentioned genetic needs. Simultaneously with realizing these needs, different processes are formed and established, during evolution, also on the basis of genetics. These processes lead to and are concomitant with marriage (or partly other close interpersonal relationships) as selection, choice partners to marriage, also showing slightly disparate criteria of the selection of women and men, taking in consideration different forms of investment in marriage and above all in offspring. In the result of such evolutionary processes women ascribe more value to the following traits of men as partners: first of all health, good genes, faithfulness, loyalty, warmth, kindness, determination, dominance (to some extent), resourcefulness and age, status or resources. In general men by women are perceived as “objects of success” (strictly for woman as wife and then mother and their offspring). All these qualities of men enable them to eventually provide any well-being for their wife-mother and offspring. When it comes to women as partners, men most value the following traits as: physical attraction, youth, health, fertility, faithfulness, fidelity, loyalty. In general women are perceived and valued by men as “objects of sex” (in the general meaning of that term, strictly rather as opportunity for procreation of and investment in healthy offspring) (Fletcher, 2002; Buss, Dantley, 2006; Lieberman, 2006; Fletcher et al., 2006; Diamond, 2004).

It is worth briefly to mention also the evolutionary approach to love proposed by H. Fisher, who distinguished the three successive/gradual
systems or stages each with different neural circuits for love, and also with its more specific hormones. And namely: the first system called lust or sex drive includes testosterone and leads to sexual union, eventually with various partners; the second attraction system or romantic love, infatuation’ is fired by dopamine and norepinephrine and is focused on single partner courtship; the third, the attachment system or companionate love with hormones oxytocin and vasopressin (Fisher, 2000; Bianchi-Domicheli, 2006). As well as is interesting also the conception of romantic relationship and falling in love and remaining in love, according to assumptions of strategic pluralism proposed by Gangestad, Simpson,. The conception takes in to account the model of the two various types of love and relationships, namely the romantic type of long-term, monogamous interpersonal relationship, based on mutual, faithful love; and/or the casual type, depending more from environmental opportunities, occasions so the short-term relation, based on sexual attraction or looking for good genes. Moreover, these two models are connected respectively with two different strategies of choice partner for procreation and investment in marriage and in offspring (Gangesstad, Simpson, 2000; Buss, Dantley, 2006; Diamond, 2004; Fletcher et al., 2006; Young, Wang, Insel, 2002).

**Neuro-hormonal Correlates of Love**

In order to try an explanation the neuronal correlates of intensive romantic love it is necessary to begin, in general, with emphasizing the activity of the subcortico-cortical reward, motivational and emotional systems; in particular the limbic system, in connection with the hypothalamus, and connection between the cingulated cortex and thalamus. Next, one should take into account the more specific cortical neural areas-neural circuits (structures), that are strictly and essentially associated with the display of various, but fundamental expressions and experiences of love in humans. First of all, great importance is ascribed to such structures of brain as the medial insula, mainly on left; the head of caudate nucleus and the puta-
men, both on the left; the ventral tegmental area; bilateral anterior cingulated cortex; bilateral posterior hippocampus; left anterior frontal gyrus; left middle temporal gyrus, right parietal lobe; cerebellum. In addition, in cases of a highly subjective feeling love and positive involvement of partners activation occurs in the antero-medial caudate nucleus and the septum fornix cortex. However, in instances of partners remaining (being) in love a long time it appears that their brains display positive (intensive) activations in right mid-insular cortex, right anterior cingulated cortex, bilateral posterior cingulate cortices, left inferior frontal gyrus, left ventral putamen-pallidum, left middle temporal gyrus and right parietal lobe. But in cases of partners solely in short or short-term and also declining relationships their brains manifested activations in the posterior cingulate gyrus, retrosplenial cortex. Yet, in the light of research appears that more fundamental regions of the brain, most likely to be involved in romantic love and also in infatuation are the ventromedial prefrontal cortex, anterior cingulated cortex, amygdala, hippocamps, nucleus accubens, hypothalamus, and regions of the brain stem (Ortigue et al., 2007a; Bianchi-Demicheli, 2006; Aron et al., 2005; Marazziti, 2005; Fisher, Aron, Brown, 2005; Fisher, 2000).

In this context, it appears that love occurs within the both subcortical, that is unconscious or subconscious, and cortical-conscious neural circuits, thus integrating emotional and reasoning or rational processes; and in this way it is possible to overcome the paradox “that love is blind and also wise”. Moreover, these findings demonstrate that intensive romantic love takes place within a modular neural network that can be differentially activated according to the potential fluctuations of mental states of love and the influences of external, environmental circumstances. Therefore, one might suppose that an intensive romantic love has not only conscious but also unconscious facilitation effects on cognitive and behavioral performance. It needs to be stressed that this assumption is very important to explain a process of falling in love, being in love or infatuation, because it is connected with the subliminal presentation of a beloved person, i.e., “romantic love priming”. Moreover, it appears, that the subliminal presenta-
tion, according to a genetically outlined program, is started by individuals in early childhood. Gradually, approximately till late adolescence, they develop a “love map”, which can also be referred to and conceived as “priming”, which is a subconscious, rather unconscious constellation of traits, behaviors, activities and various physi- somatic details, that they will later look for in a mate. Therefore, when in adolescence and later the individual falls in love on the basis of his/her priming or love map, the person whom he/she falls in love with, where he/she falls in love, what he/she finds attractive in a partner and how he/she courts a potential mate will vary from one society and one partner to the next. But once he/she find that special person and the actual emotion-feeling occurs they experience this passion lodged in the modular structure of their brain, strictly as love map. It evolved to enable individuals, at that time, to conduct a more conscious selection between potential mates and focus their mating energy on the preferred partner, who is best matching to their genetically programmed and neurologically developed and arranged “love map” or priming of love (Fisher, 2000; Bianchi-Demicheli, 2006; Ortigue, Bianchi-Demicheli, 2008; Ortigue et al., 2007b).

When it comes to the subcortical neural network it partially plays a very important role in social interpersonal relationships, especially for early stage processes of mate selection, and above the falling in love of both partners and their mutual attraction, attachment and also the neurohormonal base for a perspective function of becoming relationship, because, as is well-known, it mediates emotional, reward and motivational system (Hermans et al., 2001).

Romantic Attraction

From the scientific and evolutionary point of view romantic attraction is a universal experience of mankind, sometimes also called romantic love, passionate love, obsessive love or infatuation. As everybody knows, attraction is an altered mental state. This state with mood elation is char-
acterized by the sensation of being full of energy and strength, feelings of exhilaration, intrusive thinking about the object of love, and a craving for an emotional union with the partner or potential partner, by being certain that his or her partner is the most unusual (extraordinary) individual in the world or the best available mating partner, and at the same time decreased interest in routine or daily and mundane activities (Fisher, 2000; Marazziti, 2005).

The feeling of romantic attraction is probably associated with a high level of dopamine, norepinephrine and low levels of serotonin. The many features of the specific behavior of people infatuated or in love, in spite of the above, most important include (for example): a tendency to focus attention on the positive qualities of the beloved and overlook, falsely appraise or show only partial understanding, or misinterpret his/her negative traits, actions or deeds and, on the contrary, what is more and happens often, to focus on specific events, objects, and so on, yet all related to beloved person. On the neurological basis, with the use of the functional imaging of the brain (fMRI) it appears that the high level of dopamine is associated with increasing the demand to a novel environment, to novelty and challenge. In this context may arises the question: why this happens? In principle therefore, because novelty and challenge is typically associated with higher level of arousal, and arousal can promote or facilitate meeting an appropriate person, as well as romantic attraction to another person. In case of an attraction arousal would increase attraction to a desirable person but would decrease attraction to an undesirable one. Generally it depends on whether a highly desirable state arisen by novelty and challenge creates a sense of self-expansion, enrichment, enlargement of (some) any opportunities for example, in scope of self-esteem, well-being, status and others resources or some others expected, desirable opportunities for one partner or eventually both partners. It is worth to add, that the important influence on the strength and intensity of experienced of romantic attraction may cause some facilitators non only physical beauty, but also state or feeling of distress, anxiety, danger; state too high of general arousal caused by different situational stimuli; or sex drive; age and
oft concomitant appropriate bringing social pressure Moreover, a possibility of mutual performance of new and challenging activities, to a larger extent, increases the feeling of love and satisfaction (Lewandowski, Aron, 2004; Aron et al., 2000; Foster et al., 1998; Griffin, Taylor, 1995).

In addition, the high level of dopamine supports the tendency to focus on, remember and cherish specific qualities or traits of the beloved, as well as the tendency to remember, muse or consider, sometimes obsessively, and imagine or focus on specific moments and experiences associated with the beloved person (Fisher, 2000; Kiyatkin, 1995; Lewandowski, Aron, 2004; Griffin, Taylor, 1995).

When it comes to norepinephrine it is need to be emphasized that it also plays a very important role within interpersonal processes, also connected with love. The increased level in brain norepinephrine is associated, among others things, with increased memory for new stimuli, objects, especially persons, and moreover, with an ability to imprint or form similar, very close, long-lasting and strong relations, not only with beloved or friend, but even with strangers, which above all might be place when individual is falling in love, and especially in infatuation. However, taking into account this aspect of norepinephrine, it is first of all associated with being in romantic love. Yet, it should be emphasized that various levels of dopamine, norepinephrine or serotonin, taken together, create different compositions as a neuro-hormonal base for the functions of some areas of brain and consequently also different mental and emotional aff ects states, which are characteristic of individuals falling in love or being infatuated. Therefore, they experience altered mental states from elation, sensation of being full of energy and strength to a state of depletion, as well as mood swings from depression to joy, and/or feeling of anxiety or even fear, depending on the partner’s response. If the relationship suffers setbacks, the attracted individual may fall into apathy, brooding, and experiencing despair. Moreover, the specific behavioral models of very characteristic attraction, aiming at evoking patterns of reciprocate response or behavior similar to hugging/cuddling up or mutual clasping, and even to compulsions. The set of these symptoms is similar to the opposite phases of a bi-
polar disorder (manic-depressive), being sometimes an effect of exactly different levels of dopamine, norepinephrine and partly also a low level serotonin, and above all oxytocin and vasopressin which might be responsible for caress and hugging, and also for intrusive thinking, often associated with romantic attraction and more often with infatuation. Because these individuals report feelings of emotional dependency on the relationship with the beloved, and also specific feelings of emotional, reciprocal union, even possessiveness, and especially the powerful attachment which are more valuable than a sexual union, and simultaneously, often report feelings of jealousy, fear/anxiety of rejection or separation. Nevertheless, in general, smitten individuals feel a powerful sense of empathy toward the beloved one and willingness to sacrifice for their partners, and also a tendency to reorder their daily priorities, habits, and even their clothing, values, attitudes and beliefs in order to become more available to the loved one. On the base of those processes and in its consequences also deep changes in the scope of emotion-feelings, attitudes, some values and even personality traits occurs a revaluation or reappraisal the personal genetic kinship toward a stranger but beloved person, into a more important, significant, constant, psychological love kinship. Moreover, what is important, in times of adversities beloved individuals experience an intensification of their mutual romantic love and concomitant passionate feelings. One should stress, that the above mentioned processes are not only very important but are likely to have strategic significance to overcome new emotional, cognitive, behavioral and also existential, and even material states, arising in the new situation of falling in love or being in love. Such states may concern, first of all, general risks linked to the feeling of separation from the current family environment, fear of the unknown, uncertainty, being unsightly for the stranger, becoming non-related (without common, genetic kinship), but at this time the really beloved partner, and, reversely, who is recognized as person of the great likelihood of mutual bonding and faithfulness, and hope to create a happy future relationship with him or her, and also procreate offspring. It appears, that on the base of those processes and in its consequences also deep changes in the scope
of emotion–feelings, attitudes, some values and even personality’ traits occurs a revaluation or reappraisal the own, previous, familial genetic kinship into a more important, significant, constant, psychological love kinship toward a stranger, non-related but very beloved person (Marazziti, 2005; Bianchi-Domiceli et al., 2006; Ortigue et al., 2007a; Aron et al., 2005; Fisher, 2000 i 2005; Hatfield, Sprecher, 1986; Bailey, Nava, 1989; Rostowski, 1987, 2008).

Now, it should be emphasized that all these processes are possible to be put into effect for human individuals, above all because of the functional cooperation between genetic, evolutionary, neurological and hormonal systems (endowment) make it possible for human beings to select a partner, fall in love and create a relationship for procreation, as well as transmit their genes to future generations (Schaller, Simpson, Kenrick, 2006).

### Romantic Attachment

Now, I would once again like to return to neurohormones in the context of attachment. Omitting a detailed presentation of the early periods (infancy, childhood and early adolescence) and limiting oneself only to late adolescence and adulthood regarding attachment development, I would to focus only on selected issues concerning falling in love or being in love. It is common knowledge, that attachment can generally be defined as a social process involving a firm emotional relationship between one individual and another individual (partner) as the attachment object (target). Knowledge of attachment essentially contributes to understanding the nature and functions of romantic love. Men and women, who are securely attached, experience a feeling of closeness, propinquity, security, peace, social and personal comfort and also mild euphoria when they are in contact with a beloved partner, and separation anxiety when remaining apart for a longer period. Attachment is the most substantial component of love, and even, according to some researchers attachment is equal to love, i.e. love could not exist or could not be spoken exactly on love with-
out attachment. Bowlby argued for the existence of three basic behavioral systems that bond dyads together in love, namely: attachment, care-giving and sex. Similarly, Shaver is convinced that saying “I love you” can mean any or all of following: love as attachment, love as care giving, and love as sexual attraction (Hazan, Shaver, 1987; Fitness, Fletcher, Overall, 2007; Marazziti, 2005; Fisher, 2000; Rostowski, 2003).

Neurological and psychological studies indicate, that oxytocin and vasopressin released in the brain – are hormones primarily involved in the production of attachment behaviors and the feeling of attachment in people in the three different styles, i.e securely attached, avoidant attached, ambivalent attached. It is necessary to stress, that the basis of particular styles of adult attachment contain, to some extent, also different neural structures and functions connected with them. In the general approach, in case of the secure attachment the mainly activated structures – are the orbitofrontal and medial prefrontal cortex of frontal lobe; while in the case of the insecure avoidant/anxious style – anterior temporal pole, anterior cingulate cortex and hippocampus; as well as, (similarly) in the case of the insecure ambivalent/anxious style, yet with more diversified activation of cingulate areas (structures) (Cacioppo et al., 2007; Hazan et al., 2006; Fletcher, 2002; Carter, 2002; Goleman, 2006).

Here, it should be emphasized that the high level of oxytocin within appropriate brain’ regions contributes to the occurrence of the feelings of joy, happiness, a sense of propinquity, attachment and even euphoria, and, what is most important, to the willingness and facility to perform the difficult tasks and even sacrifices on behalf of the relationship with the beloved. Moreover, such processes may become established in the form of a conditioned reflex/response as if a form of addiction. And therefore and rather whereby each recurrence of the primal stimulus (former cue) that is, in accordance with the genetic love map or love priming, who really may be or most oft is beloved partner or both partners within an interpersonal relationship such as marriage one for another or relations of beloved partners and sometimes person only perceived till as stranger at moment of first glance, may suddenly initiates or causes activity of secretion of neurohormones. And strictly
thereby such neurohormonal activity this stranger individual becomes a close, familiar and even almost instantly intensively beloved partner, what very often happens in falling in love and more infatuation. But what is most interesting that even only potential partner–person but genetically similar and familial precisely thereby genetic love map–or love priming sometimes perceived at moment of first sight, may become the very desired and proper partner to love. And moreover, at the same time of his ongoing perception, such perception process may cause the secretion of oxytocine, vasopressin, as well as sexual hormone, and other concomitant hormones such as dopamine, norepinephrine, serotonin, causing in this way, what ought firmly to stress, that on the neuronal level occurs a beginning of process falling in love and remaining in love and also forming the above mentioned conditioned reflex or may be any kind of imprinting addiction. But in a more general approach the oxytocin also plays a very important role in the lives and relationships of adult persons, regarding the initiation, growth and maintaining of feelings of kindliness and friendship between siblings, close relatives and friends but above all the love between beloved partners, most often spouses. The secretion of oxytocin and vasopressin is also an important component of sexual arousal or intercourse, especially in the occurrence of concomitant passionate kisses, caressing, hugging or cuddling, therefore oxytocin is sometimes referred to as the “chemical of cuddling” (Carter, 2007; Taylor, Gonzaga, 2007; Guerrero, Andersen, 2000; Plopa, 2004; Rostowski, 2008).

Self-regulation in Romantic Relationships

In the context of more strict, recent and social neuropsychological research concerning various aspects of the love, one should take in account some aspects of such social processes associated less or more with the mirror neuron systems as self-regulation, reappraisal, simulation, empathy and mindreading (or mentalize). In principle, self-regulation includes the control of the processes of emotion–feelings, needs, drives, impulses,
motivation or different daily events such as conflicts, as well as processes of constraint. In the neurological approach it involves functions of the subcortical neural structures and their low roads “from bottom to top,” and more cortical structures and its high roads “from top to bottom.”

It comes to the three cortical structures associated with the executive functions, namely: 1. the ventro-medialprefrontal cortex together with orbitoprefrontal cortex; 2. the dorsolateral prefrontal cortex; and 3. the anterior cingulated cortex, they are of great importance. Upon the correct functioning of these neural structures, especially (but not only) of the anterior cingulated cortex, depend the fundamental functions of the self-regulation processes, among others, within interpersonal relations, important also in love and falling in love, as monitoring of the decision making process, initiating the selection of a new but appropriate response among many alternatives, monitoring activity and performance results, forecasting possibilities of making mistakes or evoking conflicts, evaluation benefits, rewards, costs/expenses, acquiring gains or avoiding losses or eventually punishing, and also perceiving physical, social and psychological pain. These processes are of pivotal importance not only for relationships already based on love, but especially in situations of falling in love and, above all in states of infatuation when these processes of self-regulation may be diminished or disturbed as a result of decrease in the level of functioning or damage of the above mentioned neuronal structures; in extreme cases can lead even to depression, deep changes of mood, emotional instability, apathy or compulsive-obsessive disorders (Cacioppo et al., 2007; Decety, 2007; Ochsner, 2007; Knutson, Wimmer, 2007; Sjoberg, 2006; Rostowski, 2008).

Reappraisal in Romantic Relationship

Next, in order to develop and function a close interpersonal relationship requires processes of emotional reappraisal which essentially consist in the reinterpretation of the significance of the same emotional event, yet
already in unemotional categories, and then on the basis of the processes taking place on the level of consciousness. Application of the reappraisal may have favorable or harmful effects on the interpersonal functioning within a relationship between people in love, falling in love and also infatuated partners. In principle, therefore because the essence of this process consists in cognitive transformation of negative emotions aroused at the subcortical level by unpleasant events, that then precisely are evaluated by the reappraisal again, but at the cortical level yet in other, more objective categories of real/factual state, whereby they lose their previous aversive, unpleasant character or dimension. And thereby this way the individual becomes liberated from these unpleasant emotions, for example anxiety, uncertainty, nagging doubt, fear, anger, sadness, rejection, jealousy/envy, and so on – the typical emotion-feelings in the state of falling in love and moreover in the state of infatuation. Owing to these processes associated with reappraisal it is possible to overcome the paradox that love is blind and also wise. It is should to stress that neuronal structures responsible for the process of reappraisal of unpleasant stimuli, as well as emotion-feelings are the cortical regions associated with mirror neuron systems, mainly the: 1. lateral prefrontal cortex, 2. various areas medial prefrontal cortex, 3. anterior regions of cingulate cortex, 4. dorsomedial prefrontal cortex. It need to add, that the dorsomedial prefrontal cortex simultaneously participating, on the one side, in the processes of cognitive control, and on the other side, acting as a brake on the structures responsible for arousing negative, above mentioned emotional reactions at the subcortical level, in principle the amygdala, partially the hippocampus, and also partly the medial orbitofrontal cortex. The medial orbitofrontal cortex is responsible, to be exact, for forming reappraisal strategies through modulation of different systems associated with examining and performing emotional states (Cacioppo et al., 2007; Decety, 2007; Ochsner, 2007; Lieberman, 2007; Ochsner et al., 2005).
Imitation in Romantic Relationship

The imitation (or simulation) is more process, than only ability, that is of central significance and plays a key role in the development and acquaintance of many social skills and competencies, which in turn play a pivotal role within all the close, love-based interpersonal relationships and also in the state falling in love and infatuation, consisting chiefly in reading of the facial expression and others gestures of the body, and primarily understanding goals, intentions or desires, and wishes of other people. From the neuronal point of view the recognition of the emotional expression of another person depends, at least partly, on the subset of the same neuronal structures, that have been engaged and participated in expressing the same emotion in their own neuronal circuits in the brain, associated or responsible for arousing this emotion. In the process of imitation there is a type of “empathic resonance”, and such resonance may occur even at the unconscious or subliminal level, which is possible owing to the mirror neurons systems (Herberlein, Adolphs, 2007; Turner, 2007; Havet-Thomassin et al., 2006; Lizardo, 2007; Jacoboni, Dapretto, 2006; Castelli et al., 2005).

Empathy in Romantic Relationship

The neuronal process of empathy plays the pivotal role especially within the various steps of falling in love and being (or remaining) in love and more generally in the properly functioning all of close interpersonal relationships. In general approach empathy is complex form of psychological inference in which observation, memory knowledge, and reasoning are combined to yield insights into the thoughts and feelings of others. And also at a phenomenological level, empathy can be defined as a sense of similarity between the feelings that one person experiences and those expressed by others; or as an interaction between any two individuals, with one experiencing and sharing the feeling of the other. But it to stress that this ability not always impelled to act or behavior in sympathetic ways,
it may be used for both helpful or supportive and also hurtful or even hostile purposes. It appears, that the social and emotional situations which elicit empathy can become very complex during occurring mutual interaction depending on the feelings experienced by the observed individual and the relationship of the target to the observer. In recent time the cooperation social psychology and social neuropsychology provides knowledge about the neural processes underlying empathy, whereby it takes possible description more adequate conceptual framework of empathy. It is worth to emphasize, that only by human beings empathy may be felt or expressed for virtually any target; and also emotions connected with empathy may put into words allowing to express these emotions of empathy non only experiencing in current, as well as past or even in future (Decety, 2007, pp. 246–247; Jacoboni, 2007).

According to Decety the proposed framework or model comprises four major components interacting with one another to produce the subjective human experience of empathy, mainly: 1. sharing emotions-feelings, i.e. feeling what another person is feeling often without explicit self-awareness of this process as any emotional contagion (or chameleon effect); 2. self-awareness as temporary identification between the observer and its target; 3. mental flexibility to adopt the subjective perspective of the other; 4. monitoring mechanisms and modulating and regulatory processes, finally including emotion regulation. Yet, what it need to add, that some components as sharing emotions and motor-mimicry involved in empathy occur subconsciously, implicitly without awareness, i.e. at level bottom-up; but other components such as perspective taking, representing own thoughts and feeling and also some processes of emotion regulation occur at top-down level, i.e. at cortical level with explicit participation of awareness. Here, it is need to emphasize, that humans are not just information processors, but humans are also value processors. Therefore, neuronal structures involved in processing social stimuli, for example, such as eye gaze, smile, grimace, different facial expressions and biological motions, are also sensitive to emotional contents, because social stimuli have inherent emotional value for human beings, and moreover, because emotions
being integrally associated with empathy, that is, why they just derive its meaning from evaluative social contexts (Decety, 2007; Jacoboni, 2007; Knutson, Wimmer, 2007; Decety, Jackson, 2004).

The results of different researches prove that the important way of empathizing is embodied in oneself as if expressions of face and different reactions and also attitudes of others people, as well as their mental processes and states of mind reading. In this neuropsychological approach to functioning of empathy, as well as, imitation – the mirror systems play the fundamental role mainly thereby, because they code non only external activities or behaviors of other people, but moreover also their unobservable intended states strictly connected with such activities as plans, intentions, aims, inferences, feelings, desires, emotional valuations and even inferring and imagining contents or concepts of other persons. It should to stress that often this modular complex of the above mentioned processes is called as mentalizing or mind reading, i.e. reading implicit mental states. Strictly concept mentalizing capacity refers to the broad social cognitive ability (sometimes called Theory of Mind) used by humans to explain or infer and predict their own behavior and behaviors of others by attributing to them independent mental states, such as belief, desires, emotions or intentions. More essentially it is the ability of attribution of above mentioned implicit mental states to oneself but most often to others persons in order to explain and interpret and/or forecast their activities or behaviors (Decety, 2007; Norris, Cacioppo, 2007; Ochsner, 2007; Beer, 2007; Stone, 2007; Saxe, Kanwisher, 2005; Carr et al., 2005).

It is need to add that functioning above examined mental states connected with empathy, and which play the pivotal roles in various states being in love, essentially are associated or conditioned by activities, first of all, of right bilateral temporoparietal junction (R/L TPJ), and medial prefrontal cortex (MPFC), orbitofrontal cortex (OFC), posterior cingulate (PC), superior temporal sulcus (STS), inferior frontal gyrus (IFG) temporal poles near amygdale (A), occipital gyrus (OG), fusiform gyrus (FFG). As far as is concerned to emotional aspects of empathy the three neural structures (STS, IFG, FFG) are playing the important role, because they
are strongly activated, both when individuals is processing social stimuli
and when perceived social stimuli (in itself) have emotional significance;
whereas particular emotions seem related to different neural structures
(Saxe, 2006; Beer, 2006; Stone, 2006; Carr et al., 2005; Saxe, Kanwisher,
2005; Saxe et al., 2004; Norris, Cacioppo, 2007; Jacoboni, 2007).

Mirror Neuron Systems
and Romantic Relationships

In the context and rather the connections above all with empathy and
also imitation and reappraisal, it appears that the mirror neuron systems
and those specific neuronal activities and functions, in simple, general
but essential view, consist in the processes in which a class of neurons
(just called mirror neurons) of one individual become active when he/
her makes particular action or when he observes another individual mak-
ing a similar action (Cacioppo, Berntson, 2005). Taking in account this
specific activity of mirror neuron systems it expressively appear, that these
neurons play very important role especially within close interpersonal re-
lationships based on love and in falling in love. Essentially therefore, be-
cause these neurons enable partners to conduct better mutual decoding,
understanding or recognizing and also predicting their own and above all
their partners social, personal information, intentions, needs, desires, and
so on. Moreover, and in this way mirror neurons assure perseverance and
success within these complex interpersonal relationships, that really are
responsible for performing different and often complicated or problem-
atic life tasks, and the implementation of joint undertakings. Obviously,
especially such problems face partners being in love, falling in love and in
particular those infatuated. This approach puts forward the statement that
the mirror neurons systems non only are neuronal, but in some scope and
in large sense they are also some kind cognitive mechanisms of sending
informative contents when the activated state of defined neuronal network
underlying activation in one person is shared with another person or even
many other people present or participating in a concrete situation. It happens in this way as a result of a close connection and transmission between one brain and another brain or even many other brains, influencing not only the brain, but also, through activating in this way different, but typical brain structures appropriate to the defined set of stimuli, on the body, and above all on various scopes of cognition or emotion-feelings including also physical activity and behavior. Moreover, it must be highlighted that mirror neurons not only code or decode and analyze perceptual audio-visual information or actions per se, but also conceptual processes connected above all with the goal and meaning of the thoughts, actions of both oneself and others, as well as perspective one takes on those actions. Similarly, the activity of the mirror neuron systems also include the social, neuropsychological, interpersonal processes, very important for the correct functioning of close relationships based on love, falling in love or infatuation. Such activities of mirror neurons systems, despite above mentioned self-control, reappraisal and especially imitation, empathy, still also self-cognition, and mindreading, are possible thereby taking into consideration the participation and cooperation with the mirror neuron systems so many different subcortical and particularly cortical structures of the entire brain (Lizardo, 2007; Turner, 2007; Jacoboni, 2007; Jacoboni, Dapretto, 2006; Cacioppo, Berntson, 2005; Castelli et al., 2005).

Considering role, in general, neuronal structures and particularly role of mirror neuron systems in context functioning of close interpersonal relationships and especially mutual relations partners being in love or falling in love, it is necessary to take into account in semantic approach the difference between perception, strictly person or other people knowledge and perception and knowledge generally also inanimate objects. Such differences are included a number of potentially important aspects of social, intimate behavior between two persons in love. Most obviously, the attributes used to describe persons differ substantially from those used to describe inanimate objects and even animals or vegetables. Description and evaluation of another partner-person should be considered above all, but not only, in categories of her or his internal, unobservable attributes
and also mental and emotional-affective states, i.e., states that cannot be directly observed but may instead require generalization from one’s own internal psychological processes or properties (above mentioned) that are included in Theory of Mind. Therefore, normal, intuitive and even semantic application of person knowledge for the properly going interactions between interdependent partners in love demands special flexibility and selective forms of evaluation of mutual behaviors and reactions to them, especially in trouble and simultaneously important individually or socially situations for the guaranty the favorable continuation of their mutual love (Stone, 2007; Mitchell et al., 2005; Haxby et al., 2005; Saxe, Kinwisher, 2005).

If comes to neuronal base underlying the above mentioned psychological processes the important and modulated role play, in modular way, very different brain areas, including first of all dorsal and ventral areas of the medial prefrontal cortex (MPFC), right intraparietal sulcus (IPS), right fusiform gyrus (FuG), left superior temporal cortex (ST) and medial temporal cortex (MT), left motor, and regions of the occipital cortex bilaterally. It is worth to underline that there are some differences among neural structures more connected with person knowledge in comparison with animal or object knowledge. Yet the very interesting and important is the fact that the three neuroanatomical structures/regions with the notably high resting metabolic rates are associated with person knowledge, namely: dorsal and also ventral medial prefrontal cortex (MPFC), lateral and medial parietal areas with inferior parietal sulcus (IPS) (Mitchell et al., 2005, 60; Gusnard, 2006; Gusnard, Raichle, 2001).

Moreover, this fact is most important yet therefore, because of the circumstance, that such neuronal structures with high resting metabolic rates in brain associated with mirror neuron systems may reflect high levels of spontaneous, continuous, active mental processing, that take place even during resting states; and what is more important, that the above mentioned neural structures are consistently associated with the social-cognitive processes, such as the imitation of other mind, the perception of socially relevant stimuli, empathy, the flexible use of social and moral
knowledge, self-referent memory, emotion regulation. The above debated neuronal regions (structures) and related neuronal processes characterized by high resting metabolic rates are connected and underline functioning mirror neuron systems and thereby the mirror neuron systems within these above mentioned neuronal regions play so very important socially or individually functions, such as previous warning system before danger or other surprising, unexpected but possible to forecast events, behavior, information, encounters, both good or bad, and so on. And in this way they enable people in forms of any sense, an unclear impression, (pre) feeling, intuition or biomarkers, to forecast or interpret such unexpected events and its potential results, and also eventually prepare to react or cope with them. One need to add, that this kind of processing operations first of all may occur spontaneously, at each time even during resting state, whereas following, second reaction already after consciously perceived stimuli produces little only partially deactivation or no deviation from first baseline level of metabolic rate for these typical neuronal region, because these two processes, first spontaneously occurring and second consciously by stimuli activated, yet more often overlap. Moreover, finally it should to state that above debated neural, cortical structures continuously functioning at high levels metabolic rates are above all and essentially responsible for many, pivotal aspects of processes connected with being in love and also falling especially falling suddenly in love and much more infatuated and also quality levels of functioning and satisfaction of close interpersonal relationships based on love (Mitchell et al., 2005; Gusnard, 2006; Beer, 2007; Gusnard, Raichle, 2001; Gusnard et al., 2001; Haxby et al., 2005; Fletcher et al., 2006).

In sum up, it should expressively emphasize, that positive functioning of the mirror neuron systems explicitly indicate on occurrence of the general propriety and the specific ability of human brain that makes possible to once more, even many times, repeatedly utilize and take advantage the similarly defined and formed set of neuronal processes for performing similar goals or tasks. This ability underlines non only the self-regulation, reappraisal, imitation or empathy, but also the various types of imagina-
tion, most importantly, the thinking, reasoning, others mental cognitive processes, and even the volitional states. From the other side, possibilities associated with the mirror neuron systems may also indirectly underline social interpersonal cognition in the scope for bias, misunderstanding, use inappropriate attributions, erroneous heuristics, prejudices, even conflicts. Therefore also in modular approach especially in scope of social cognition and behavior it is necessary to use also the semantic systems to analysis of social situations. That is, processes non only based on neural temporal, parietal, temporalparietal junction regions associated more directly with mirror neuron systems, but simultaneously also on other executive functions of prefrontal cortices of frontal lobe, especially medianprefrontal cortex and above the ventromedialprefrontal cortex most responsible for normal, objective-rational, more probable correct processes of control and making responsibly decisions. It is necessary take in account those processes of the pivotal importance for normal, appropriate interactions within the close relationship based on love as the marriage or relations between beloved partners. Here, it should to emphasize the fact, that our knowledge about functions of the mirror neuron systems now is still incomplete. Precisely, it is only at initial state, but one may expect that further investigations on the mirror neuron systems within social neuroscience, of course, step by step will discover and explain more completely and satisfactory this kind of neuronal processes influencing on various forms of human activity and social interpersonal behavior and also love. It needs to be explained, in order to avoid of eventual misunderstanding, that the mirror neuron systems are only one of means, but important to attain correctly social understanding and cognition. In order to achieve a more solid, competent social understanding of only human love we should use also the semantic system, based in more extent on reasoning, contents of memory, previous experiences and concomitant context, and so on. Nevertheless, it needs to be emphasized that the two systems do not exclude each other, but rather are complementary within the framework of activity and executive func-
tions of the prefrontal cortex of the frontal lobe (Lizardo, 2007; Turner, 2007, Muthukumaraswany, Johnson, 2007; Saxe, Kanwisher, 2005).

It need to add here, that in a similar, complementary way function also the above examined genetic, evolutionary and neurohormonal approaches to love.

It worth still to emphasize the fact that for processes of development, maintenance, maturation and above expression of love are responsible both, i.e neuronal subcortical and cortical structures associated with subconscious rather unconscious and also mainly conscious processes and functions, respectively. Moreover, but for the actual expression of love by different individuals are responsible nearby the same module of neuronal structures and functions, but individual differences of expression ways are conditioned by different levels and quality of functional fitness of these neuronal structures, and even hemispheric asymmetry of brain, that is, if they function normally, correctly, or disturbingly, pathologically, improperly, and even detrimentally. Finally, I would think, that those debated and explained approaches may be helpful in the cognition of the really very important, but often omitted individual differences in the scope of manners experiencing and expressing feeling of love, and also might to contribute to a bit better understanding non only the bioneuropsychological aspects of the base of human love, but also and even if indirectly also, one might suppose, to shed new light on the different cognitive, behavioral and cultural approaches to phenomenon of love.

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