LESSONS FROM BEHAVIORAL SCIENCE FOR THE NEUROSCIENTIFIC INVESTIGATION OF LOVE

Elizabeth Clark-Polner, Margaret S. Clark

Abstract

Neuroscientific approaches are actively being used to gain intriguing and valuable insight into the nature of love and relationships. There is a simultaneous burgeoning of behavioral research on the nature of love, affection and support in relationships, but these literatures have remained largely segregated from each other. In this paper, we put forth a few strategies for facilitating the coupling of current neuroscientific efforts with up-to-date theory and findings from the behavioral research conducted by social and personality psychologists. Specifically, we make suggestions as to how to import knowledge from current behavioral relationship research to neuroscience to aid in 1) the conceptualization of love, and 2) the design and conduct of studies to examine it. To illustrate, we discuss the concept of responsiveness in close relationships (one characteristic of successful romantic relationships, friendships, and family relationships), and the ways in which the construct of responsiveness may highlight novel ways to identify love (or a lack thereof) for the purposes of future research. We then discuss the ways in which this might influence future neuroscientific studies of love. In essence, this paper is a call for closer collaboration between relationship scientists generally, and neuroscientists interested in relationships in conducting research on the nature of love.

Key words: love, relationships, neuroscience, communal relationships

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Elizabeth Clark-Polner, Université de Genève
Margaret S. Clark, Yale University

Corresponding author
Elizabeth Clark-Polner, Université de Genève, Office 4172, UniMail, Boulevard du Pont d'Arve 40 1205 Genéve, Switzerland. Email: Elizabeth.Clark-Polner@Unige.ch

Introduction

Love is categorically complex – a poster child for a phenomenon (or, more correctly, for *phenomena*, as this term is used in myriad ways) the study of which must strive for conceptual precision, and make use of multiple, and various, methodological approaches. To the latter end, the field of neuroscience has recently made significant contributions to the literature on love, demonstrating the utility of novel and intriguing approaches including neuroimaging, and neuro-biological analyses, to answering perennial questions about the nature of love. The methodological paradigms and theoretical foundations that this recent literature utilizes, however, differ in notable ways from those that underpin the more traditional behavioral research in this realm. These two literatures – the behavioral, and the neuroscientific – have remained largely segregated, despite sharing an ultimate goal. As each field can learn from the other, and as researchers interested in love will benefit most from their *synergy*, bringing the two together is important. To that end, the current paper aims to highlight a few of these differences between the two approaches, and to discuss some ways in which reconciling them may benefit the literature on love as a whole.

The extant literature

The findings emerging from the relatively recent neuroscientific attempts to understand it are interesting and intriguing (for a comprehensive review, see: Hatfield & Rapson 2008). Researchers utilizing brain imaging, for instance, have begun to examine and to report on neuroimaging data that may help to identify the neural correlates of love. Bartels & Zaki (2000), for example, compared activation within the brains of participants when looking at someone with whom they reported being "truly, deeply, and madly in love", and when looking at friends, and found unique patterns of brain activity associated with viewing the participant-identified intimate other, as compared to the control (friends) group. Specific activity was noted in the caudate nucleus, which is associated with motivation and goal-oriented behaviors. Subsequent studies replicated this finding (see, for example: Aron et al. 2005, Bartels & Zeki 2000).

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Building upon those studies, more recent research has examined the validity of colloquial distinctions between different "types" love, as it exists in different contexts (e.g. romantic love; maternal love; platonic love). This has been done by testing for differences in the neural correlates of participants' viewing and/or thinking about targets with whom they have (self-identified, except in the case of mothers, who were assumed to love their children) love relationships of different types. Differences in the neural correlates of these different varieties of love may support the idea of these "types" being natural categories, whereas a lack of differences may imply that they are culturally, or semantically, imposed. In this way, researchers have already examined so-called passionate love, unrequited love, love for one's children, and compassion for the disabled, among others (see: Aron et al. 2005, Xu et al. 2011).

Of note is that this latter research still follows the same basic paradigm that the original investigations did: Experimental conditions are formed based on participants' self-reported experience of "love", or, in some cases, researchers' understanding of a participant's relationship, based on an interview, in which he or she may ask about the duration or "intensity" of the love relationship, or the percentage of the day the participant thinks about his or her partner (see, for example: Fisher 2004, Hatfield & Sprecher 1986, Ortigue 2007). Love (or the analogous feeling(s) for a non-love partner) is stimulated by having the participant view and/or think about, alternatively, the partner, and a control target (usually a "close friend"). There are some exceptions, where love has been stimulated in ways other than conscious thinking and/or viewing (see, for example, Ortigue 2007), but imaging studies have by and large followed this paradigm.

Research on the neuroscience of love is, of course, not limited to the examinations of neuro-electric activity, however. Studies on the *chemical* correlates of love in the brain have also provided valuable new insight into love, and potentially a new vocabulary with which to describe it. As with the imaging studies noted above, researchers have done this in part by investigating links between self-reported reported feelings of love and bodily levels of different biochemicals, including testosterone, and serotonin (Fischer 2004, Liebowtiz 1983, Marazziti 2005, Marazziti et al. 1999). The most common paradigm for this research has investigators comparing levels of these markers in people who report being in love, with those who say they are not in love or those experiencing other states (obsessive-compulsive states, for instance).

Notably, however, in the literature on the chemical correlates of love, there are also more varied operationalizations of love. Researchers have examined, for example, how different biomarkers are associated with different events, which are commonly and theoretically thought to be themselves associated with love. Recent studies, for example, have examined the production of the hormone oxytocin as it is linked to birth, lactation, intercourse – all potential correlates of close relationships. There has also been research which has looked at the ways in which oxytocin is related to bonding to fellow humans, and how exogenously administered oxytocin may predict (in some cases) enhanced prosocial behaviors toward others (e.g. Kosfeld et al. 2005). Upon the basis of this research, some have concluded that oxytocin *is* the love molecule, or a love drug[1] (Zak 2009).

The conclusions that have been drawn from these studies as a whole have varied, but have included claims that love *is* a reward, love *is* an emotion, love *is* a motivation, and love *is* akin to a sickness, or that hormones such as oxytocin can create love. Yet neuroscience is new to the study of love. Neuroscience as a whole has yet to cull a common, clear, construct(s) regarding what love is, and many (not all) typically do not to consider it as more than neurochemical reactions or patternings of brain activation, indicative of an emotional or motivational reaction to a stimulus that occurs at a discrete point in time. It has yet to conceptualize love in intra- as well as interpersonal *process* and *functional* terms that unfold across time. This will be necessary, in order to reconcile these exciting new findings with those compiled by other areas, which have considered love from these perspectives. Additional work should continue in the direction of the more varied operationalizations noted above.

A related point is that the neuroscientific work remains largely unconnected with the larger social psychological enterprise of understanding love, attachment and behavior. Connecting neuroscience research to the larger research enterprise of coming to understand love, affection, and close relationships, will be necessary for the realization of the full potential of neuroscience to enlighten the study of love. Some steps that might be taken to achieve this end are discussed in this paper.

In what follows, we put forth our view that greater, more systematic, contributions could be made, and more comprehensive conclusions drawn, if neuroscientists and traditional relationship researchers collaborated more closely, with both sides making efforts to integrate that which we have learned about love from extensive social and personality research on the nature of close relationships in general, and experiences of love in particular. Specifically, we focus on the experimental design phase of neuroscientific research on love, and posit that scholars pursuing it can use existing relationship theory and empirical findings to: 1) set forth clearer conceptualizations of love; 2) move in informed ways toward studying not just static

states of love, but the interdependent processes that have been previously demonstrated to be part of love and that unfold across time; 3) obtain more reliable data in any given experiment by more effectively selecting and grouping individuals for participation (e.g. separating those who are in love from those who are not according to a clear set of criteria; and those who are better able to enact certain forms of love from those who are not in the same way) ; and, finally, 4) more effectively elicit loving feelings and love related

[1] Others, however, urge more caution, pointing out that administration of oxytocin often has no overall effects on behavior or judgments and also, not uncommonly, results in heightened envy and antisocial behavior.

processes in the laboratory – that is, to go beyond having a person simply picture, or think about, a beloved partner.

Taking these steps will almost certainly enhance not only the neuroscience-specific understanding of love, but also our overall understanding of love, as what is known about brain function and the meaning of various patterns of activation in brain regions, hormones and neurotransmitters can feed back, and help to verify or correct current social psychological understandings of love, and to suggest new theoretical ideas to traditional relationships research.

Issues in the extant research

Conceptualizing love

"Love" means different things to different people. To some it is captured in passionate sexual feelings. To others, it is embodied by mutual caring. Some experience love as one-sided; others as reciprocal. Love has been described as exhilarating, but also as involving a sense of calmness and security. At times it can be wonderful, but the same relationship may also cause pain, if circumstances change. The Oxford English Dictionary alone lists more than 800 distinct uses of the term, and psychologists themselves have defined love in many different ways. Simply put, a reference to "love" appears to be fuzzy.

This fuzziness has been demonstrated empirically: Fehr (1988) has performed a prototype analysis of the ways in which people use the term "love", and found not only that there is no one way in which it is used, but also that there is neither a sufficient, nor a necessary, set of attributes for its use. People, it appears, do not define love for themselves in clear ways with clear boundaries. Instead they find a number of attributes that together suggest the presence of love with some of these attributes tending to be more central to their conceptualizations – e.g. trust, caring – and others more peripheral – e.g. butterflies in the stomach).

Whereas this fuzziness may be fine colloquially, good *science* demands clear conceptualizations of the constructs under consideration. To the extent that this term – "love" – may understood differently by different people, or by the same people in differing contexts – there may be significant unnecessary noise in the construct(s) examined by studies that identify the existence of love (or a lack thereof) using this terminology. Working to reduce that noise, and to note its presence where it may be unavoidable, will allow neuroscience to make even greater contributions to the description of love than it has already.

Leaving the definition of love to the participant. In a large proportion (if not the preponderance) of the love literature – across experimental disciplines, not just in neuroscience – the act of defining the construct under consideration has become the responsibility of the participant. This happens when participants are recruited upon the basis of self-identification of being in love, and it introduces significant noise into the research process (see Fehr 1988). Noise is also introduced when participants are themselves responsible for choosing the experimental stimuli, in the form of self identified loved, and close, but not "loved," others (e.g. choose someone with whom you are "truly, deeply, & madly in love" Bartels & Zeki 2000, or just someone who is loved, Cheng et al. 2010), in studies which contrast reactions to stimuli evoking the "loved" person to reactions to familiar, but not "loved" others (which is many, this being a popular manipulation).

To give one, important, example, we now know well that there are very important differences between individuals in terms of how much they trust other people and are willing to depend upon them, versus failing to trust others and engaging in considerable self-protection and risk avoidance (see, for example: Clark & Lemay 2010, Downey & Feldman 1996, Murray & Holmes 2012, Mikulincer & Shaver 2012). These differences almost certainly result in people experiencing love differently, to the degree that love is communal (Clark et al. 2010, Clark et al.1989). This suggests that, at a minimum, individuals should be screened in terms of such differences after self-identifying as being in love, for they likely experience that love differently, and this differential experience may be of theoretical importance to the researcher.

Another strategy likely to prove useful is for the researcher not only to define experimental conditions in ways that are conceptually defined, but also to go beyond simply dividing love into passionate and companionate categories. That distinction is a very important and still valid one, made by pioneers in this field (Berscheid & Walster 1974), but far more is now known about each of those states, specifically the variations that exist within them. Again we would emphasize the now large volume of work suggesting that issues of trust, anxiety, avoidance, self-protection and so forth should be considered in conjunction with those two broad categories. Not everyone loves passionately in the same way; not everyone loves (or tries to love) companionately in the same way. Moreover, relationship stage makes a difference to how people experience both types of love (Clark & Beck 2011, Beck & Clark 2011). It is important to further conceptualize both types of love within the current experimental literature, and past behavioral research provides useful guides.

Thus, what a large proportion of the current neuroscientific literature on love has likely studied is not a single construct, as has been commonly assumed, but rather a heterogeneous "love" soup – an artifact of participant self-selection into categories defined by a colloquially nebulous concept. At this point, it matters neither to what degree the researcher's own conceptualization has been refined (if that refinement is not conveyed to participants and has not restricted who is included in a study and on whom they choose to report), nor what that conceptualization is, specifically – a great deal of the data being interpreted as reflecting that concept will, in reality, be immaterial, and thus, importantly, misleading. One of the primary tasks, going forward, for studies of love will, thus, be to figure out better markers of love clearly conceptually defined and linked to specific types of love a researcher wishes to study.

Notably, when love has not been clearly,

conceptually, defined it has also been the case that little effort has been made to record participants' personal definitions of love. Recording such personal definitions, variable as they may be, might allow for retrospective culling of a homogenous construct to study. So doing may be one solution to the above-mentioned problem, though it assumes that participants have conscious access to the necessary information, which may not be the case. Alternative solutions are suggested by some of the theoretical and experimental work done within social psychology (including solutions to the social desirability concerns inherent in asking participants about their love lives directly). (We will describe some of this work, as well as potential solutions it might suggest, in the second half of this paper).

In addition to noise introduced into experimental data as a result of participants' variable definitions of love, researchers' variable definitions of love introduce unnecessary imprecision in the *interpretation* of those data. Critically, this variation is not always necessarily apparent, because researchers' definitions of love are often un- or under-defined – e.g. (Karremans et al. 2011, Suslow et al. 2009, Suslow et al. 2010). Thus, overall, interesting results *have* been obtained that are relevant to understanding love, but because both researcher and participant definitions are under-specified, it is hard to fit them together to be able to say just what we know or do not know about love in its various forms.

An ironic example can be made of studies in which researchers have tried to differentiate different "types" of love. Here, some have assumed that different categories of relationships (e.g. mother-child, romantic, friendships, relationships between care-givers and disabled people) capture different kinds of love (e.g. Nariuchi et al. 2008 for instance chose to study mother-child love; Beauregard et al. 2009 choose love for a disabled individual), but this is done without stating what the nature of that love is assumed to be in conceptual terms. In some cases characteristics of love (e.g. sexual interest) may coincide neatly with the different categories of love that have been chosen. Sexual interest, for instance, may occur almost exclusively within romantic relationships, but other characteristics of love (non-contingent caring for the partner's welfare) may crosscut many of these types of relationships occurring in all those mentioned above. Still other characteristics of love (e.g. being willing to be dependent upon another person) might occur in more than one (in romantic love and friendships, for instance), but not in love for a young child or love of the disabled. Put another way, whereas participants' have too many different definitions of love, researchers, in this case, may not have the "right" ones in conceptual, functional terms.

Unlike with the problem of identifying better markers of love, the solution to this problem is pretty straightforward – future work should be as careful as possible to clearly define the conceptualization of love it uses (including the conceptualizations of other "types" of love, if it is defining something in contrast), in as much detail as possible. To the degree that this may be difficult because of a relative lack of literature on some "types" of love within neuroscience (familial love, platonic love), extant social psychological work may be helpful in suggesting solutions. Below, we will describe the some ways in which we think this extant research may be informative.

Issues of variation in conceptualization aside, recent social psychological research may have great import for the nature of those conceptualizations themselves. Most existing neuroscience studies of love take a "snapshot" of love at a given point in time (something, to be fair, that is true of many social psychological and personality studies of love as well). The emerging consensus in relationship science, however, is that most love inheres in the very nature of interdependent ties and processes that unfold and feedback upon themselves across time. We thus urge neuroscientists to consider love as captured in process; not just a state, and discuss below how this may be done in practice.

The experimental elicitation of love

How do you isolate love, experimentally? Ideally, you could up-regulate the constituent process(es) such that you get a stronger signal. Many neuroscientists do this now by exposing people to stimuli symbolic of a loved one (e.g. pictures or names of beloved partners.) Whereas this approach seems intuitively effective, as well as experimentally so – in response, researchers have observed unique patterns of activation in the brain, as contrasted with the patterning associated with gazing at familiar, but not beloved, faces or names – the issue just raised about the need to define the type of love one wishes to study raises questions as to what, exactly, this activation is reflecting.

To us it seems well worth asking, just what kind of love is gazing at a partner capable of eliciting? Does love lie just in a person's reaction to looking at a partner? If love is to be conceptualized in more interdependent and process terms, how can it be effectively elicited in a laboratory setting with a person confined in a scanner? As above, these are questions to which we think the social psychological literature may already contain potential answers.

Social psychology and the neuroscience of love

Social psychological definitions of love

Psychologists themselves have defined love in multiple ways (for a detailed review, see: Reis & Aron 2008). Among the first scholars to address this issue were Rubin 1970, 1973; Berscheid and Walster 1974; Walster et al. 1978. Rubin (1970), for instance, differentiated liking from love, and developed self-report measures of each. Liking, he suggested, includes thinking that a partner is well adjusted, as well as the desire to be like that partner. Love, on the other hand, includes feeling that one can confide in the partner, negative feelings if one can not be with the partner, and the willingness to do just about anything for the partner. Berscheid and Walster differentiated passionate from companionate love, and defined each (Berscheid & Walster 1974, Hatfield & Rapson 1987, Hatfield 1988): Passionate love involves sexual interest, arousal,

and, often, misattribution of arousal to love (Dutton & Aron 1974, White et al. 1981). In contrast, companionate love involves feelings of friendship and companionship, and measures of this exist as well (e.g. Grote & Frieze 1994).

Some 10 to 15 years after Rubin, Hatfield, Berscheid's work, Sternberg set forth a triangular theory of love that received much attention. It includes the constructs of intimacy, passion, and commitment, which, he noted, could be combined in different ways, to form what he posited were eight unique types of love (Sternberg 1986). According to Sternberg, intimacy involves feelings of warmth, understanding, communication, support and sharing. Passion involves feelings of physical arousal and desire and sexual longing, and is not limited to sexuality. It also includes feeling any emotion for one's partner. Commitment is defined as the intention to stay with the partner. Sternberg then used these three constructs (in various combinations) to specify a variety of types of love. For instance, liking exists when intimacy is high but passion and commitment are low, and empty love occurs when there is high commitment but low passion and intimacy. Infatuation is strong passion in the absence of intimacy or commitment – a type of love that likely overlaps with unrequited love, which Baumeister, Wotman and Stillwell (1993), have defined as feelings of romantic, passionate attraction to someone who does not return that love. Sternberg too has developed self-report measures of each of his conceptually defined types of love (Sternberg 1987).

Sociologists have also gotten into the business of defining love, with the one to whom relationship researchers have paid most attention being Lee (1977, 1988), who described eros (including motivation for picking the person with the right physical characteristics and forming an intense relationship), ludus (including playfulness), storge (including lasting commitment which is slow to develop), mania (including demandingness and possessiveness aim at the beloved and feeling out of control), agape (an altruistic form of love demanding nothing in return) and pragma (involving attraction for a person with the right job, age, and religion for practical reasons). The list of conceptualizations of love could go on. Do these definitions provide additional utility to neuroscientists, above and beyond simply asking individuals whether or not they are in love?

The answer is both yes and no. Conceptually, these definitions *are* useful for pulling apart different types of love. For example, the distinction between passionate and companionate love is an important one. So too are commitment, passion and intimacy distinct constructs. One would thus not expect the neural correlates of each to be the same. It is important to pull them apart in any study. Scales developed to tap these sorts of love could be used to select participants experiencing different types of love, for example. Yet, caution is in order. The definitions above were set forth in the 1970s through the mid 1980's. The scholars behind them were pioneers in the field. Yet, in the years since those doors opened, much research on the *processes* characterizing different types of love has been conducted, further clarifying and elaborating our knowledge of all these conceptualizations of love.

Thinking about love as a process. If neuroscientists truly wish to understand the nature of love, it is essential to examine the dynamic interdependence that develops between two people and constitutes, for example, romantic passion, or responsiveness. See, for example, Clark & Lemay (2010) or Reis & Clark (in press) for a discussion of the nature of love embodied in responsiveness; Murray et al. (2006) for an in depth discussion of a risk regulation model in close relationships; Mikulincer & Shaver (2007) for a discussion of attachment related processes; or Maner's work on the dynamics involved in being passionately drawn to another person (Maner et al. 2009, Miller & Maner, in press). For an up-to-date and broader collection of descriptions, see Simpson & Campbell, in press.

Current work on passionate love, for example, clearly indicates that passionate love is not a static reaction that one person has toward other, that will be the same each time the person thinks about or seeks out the other. Instead, whereas it may be initiated by such things as a partner's physical attractiveness (Sangrador & Yela 2000), it has conscious and unconscious components, and is also up-regulated at times, for instance by scents associated with women at the mid-points points of their menstrual cycles (Miller & Maner 2009, in press) and down-regulated in other circumstances, for instance by one's commitment to a *different* romantic relationship (Maner et al. 2009, Miller & Maner in press). Moreover, it is influenced by transient states of arousal (e.g. Dutton & Aron 1974, White et al. 1981).

Current work on responsive caring love (which likely overlaps with earlier conceptions of companionate love, eros, agape, intimacy) also implicates a host of both intra- and interpersonal processes. It is associated with enhanced attention to partner needs and desires, the tendency to see virtue in partner faults, reduced anxiety when in the presence of partners, feeling pleasure in partner accomplishments, approach tendencies, acceptance of partner foibles, accommodation reactions in the face of partner missteps, and a willingness to reveal vulnerabilities and the ability to do so without fear, and the list could go on (see Clark & Lemay 2010).

All the processes now known to shape the very nature of different forms of love are not and cannot be outlined here. What is important is to know that to capture the nature of love, one must understand the nature not only of the static characteristics of individuals in love, and of their relationship, but also, crucially, of the *interdependent processes* occurring between them.

Social psychological measurement of love. We noted above the need to keep in mind that asking about love may not be the most efficient way to gather accurate and precise data. Researchers can certainly use existing measures of different types of love, as mentioned above (i.e. those of Berscheid, Hatfield, of Grote & Frieze, or of Lee), or any of a number of other self report measures of love – and there are many (e.g. Mills et al. 2004, Hatfield & Sprecher 1986, Hendrick & Hendrick, 1986) – with which to correlate and validate neural indices of love. We would urge, however, the use of additional, more implicit, measures, which

get at the processes that comprise love, and which take into account self-report biases.

Having detailed theoretical definitions of love at hand, especially ones based on process models, will allow us to identify many empirically grounded cognitive and behavioral proxies for the existence of love that might be made use of in neuroscience studies. There are a huge number of possible constructs this regard. Some are obvious; some are not:

To start with an example of the former, if one defines love as responsive caring, then it could, for example, potentially be indexed by responses to signs of another's distress. Those who care should show heightened reactivity to partners' distress, as well as signs of thinking about the partners, rather than themselves (see, for instance, Clark et al. 1987, Simpson et al. 1992). Alternatively, consider a less obvious example, and one already captured in some recent neuroscience research: Karremans and colleagues have demonstrated that although social exclusion is associated with activation in brain areas implicated in the regulation and experience of social distress (including areas of the lateral and medial prefrontal cortex, ventral anterior cingulated cortex and hypothalamus) this was less true of securely attached individuals. These researchers also found that reminding secure, but not insecure, individuals of that attachment by reminding them of their secure relationships attenuated such activation (Karremans et al. 2011). This attenuation of responses to distress when reminded of one's partner is, we suspect, good evidence of one process involved in responsive, loving, relationships – the fact that thoughts of one's partner are soothing and alleviate distress. This effect could also be considered one possible indirect marker of a relationship that may comprise love, for the purpose of future studies.

Selecting participants. How else might social psychological and personality theory form a basis for selecting participants for neuroscience studies of love? One possibility is to select people according to their self-report measures of experiencing (or not experiencing) a particular kind of love. Here we would urge researchers not to just stick with the older, extant, measures but also to develop new ones based on current work. Another possibility is to select participants upon the basis of individual differences in self-esteem, attachment style, or rejection sensitivity - a great deal of knowledge has accumulated suggesting that these measures may be related to the capacity to love in a variety of intra - and interpersonal ways (Brennan et al. 1998, Mikulincer & Shaver 2007, Murray & Holmes 2011).

Segregating people by the attachment style or communal strength of particular relationships. It is perhaps easiest to segregate participants in studies of love according to chronic individual differences measured by easily accessible scales. That it is likely to be productive to do just that is evident from the results of the many studies that have examined links between exogenous administration of oxytocin and social perceptions and behaviors toward others in the last ten years: Early work showing that nasally administered oxytocin produces jumps in empathy, as well as cooperation with, and generosity toward, others has generated much excitement (e.g. Kosfeld et al. 2005) and considerable media attention that continues to this day. Indeed, some have called it the "love drug" and Zak (an author on the 2005 study cited here) has taken to calling himself "Dr. Love", and has just published a book in which he dubs oxytocin the moral molecule[2]. Yet a review of the literature more broadly shows that exogenously administered oxytocin does not have this effect on all people (nor in all situations).

It actually decreases, for instance, cooperation among those suffering from borderline personality disorder (Bartz et al. 2011), and it is possible that might do the same among individuals or groups known to have trouble trusting others, including people with insecure attachment styles, and those sensitive to rejection.

Beyond suggesting that it may be useful to group people according to individual differences in the overall tendency or ability to trust, existing behavioral research suggests that, within the individual, differentiating between the strength of each relationship may also be useful for neuroscientists. After all, we know that love in its various instantiations varies most not between people but between relationships (see, for example, Lemay & Clark 2010 for a discussion of this as it pertains to responsive love). These distinctions already appear within the literature on love, but only in the most broad terms (e.g. romantic partners vs. friends). The current literature, however, clearly documents that even within the groups of relationships called friendships, romantic relationships, and family relationships, for example, there is significant variation in terms of the extent to which participants are anxiously or avoidantly attached, and in terms of their communal strength toward their partner, and their partner's communal strength toward them (see, for instance, Mills & Clark 2004, Monin et al. 2008, Clark & Finkel 2005b). This is true over and above (and independently of) individual differences in attachment styles or communal orientation. Neuroscientists might usefully stratify people within individuals' social networks along conceptual dimensions relevant to love, and study individual responses toward different people in their own social network.

Segregating people according to relationship stage and whether a commitment to a partner has been made. Yet another dimension along which it may be useful to stratify potential participants in studies of love, is relationship stage. Experiences of love upon first encountering and being attracted to a person will differ from those involved in initiating and building relationships, and those experiences, in turn, will differ from the experience of love if and when a firm commitment to a partner has taken place (Beck & Clark 2010, Clark & Beck 2011, Gagne & Lydon 2001). During initial attraction, people are focused on the potential partner, and that partner's attributes – such as physical attractiveness – may play an especially important role in driving feelings of love. When people

[2] To be fair, most others in the field have not jumped to such simple conclusions as easily.

are initiating a relationship they will be busy further evaluating the person as a potential partner for the self, presenting the self to the potential partner in strategic ways, and protecting the self-from possible rejection. Once commitments have been made, people will, ideally, drop many of these efforts and settle in to an implementation phase of the relationship during which they may hold positive illusions of their partner, be especially likely to be comforted by their partner's presence, and so forth. Simply put, the very the nature of love shifts over time in relationships.

Eliciting feelings of love; eliciting processes involved in love. Finally, we believe existing social psychological research will be useful to neuroscientists in the choice of ways in which to stimulate the experience or processes that comprise love. For instance, if a researcher decides it is initial passionate attraction that he or she wishes to study, then research on the very nature of physical attractiveness is available, and clearly suggests to whom people especially might be most likely to react with physical desire (Rubenstein et al. 2002). Other research suggests ways to manipulate power (Kunstman & Maner 2011), or scents (Huh et al. 2008), to heighten sexual interest in others. Researchers might also, for example, wish to stimulate a sense of commitment to an established partner in order to down-regulate passionate attraction to a different, alternative, partner (Maner et al. 2008).

Alternatively, if it is responsive love in which one is interested, the literature suggests that one can elicit a desire to be responsive by choosing people anxious to form new friendships or romantic relationships, while varying an attractive partner's availability, to make it relatively high, or low (Clark 1986). Actual responsiveness can then be elicited by providing the same people with an *opportunity* to be responsive (Clark et al. 1987). In established, trusting, relationships, one should be able up-regulate desire to be responsive to partners by exposing people to partner needs or desires, even when those people cannot take action to care for the partner (see, for instance, Monin et al. 2010).

Although not mentioned to this point, it is very important to note that, among people low in trust of others, such stimuli can set into motion processes antithetical to effective responsiveness, and cause the individual to distance him or herself from the partner (Simpson et al. 1992), or to respond with hostility or rejection in the face of expressed partner needs. This is most likely to occur when people do not trust others, and wish not to be pulled into depending on partners. (This point provides another illustration of just why researchers may first want to group people by individual differences in characteristics related to the experience of love, including attachment style and/or the tendency and ability to trust others).

Considering social context carefully. A consideration of how situations influence people has always been at the heart of social psychology. Within the social psychological community of relationship scientists, theorists in the interdependence tradition (e.g. Kelley et al. 2003, Murray et al. 1997) have played an especially important role in emphasizing the importance of social context in shaping the ways in which people relate to one another. When considering effects of neurochemicals, or when characterizing how individual differences relate to brain activation, it will thus be especially important to consider social context, for it often makes a significant difference.

The accumulated work on effects of exogenously administered oxytocin on reactions to others is a good illustration: In this work we can see not only the importance of individual differences in personality, as described above, but also the influence of social context. If situations and people are non-threatening and oxytocin is administered exogenously, pro-social behavior may result (e.g. Kosfeld et al. 2005). If they are threatening, however, the administration of oxytocin often elicits increased *anti*-social reactions and behaviors (e.g. Bartz et al. 2011). Behavioral research in the attraction and relationship tradition, has, furthermore, identified many situational cues that are likely to signal safety versus threat, and, which may therefore moderate whatever impact chemicals such as oxytocin have.

By examining how the effects of exposure to neurochemicals may vary by context, researchers will be better able to identify the roles of these chemicals in the process of love. In the case of oxytocin, a consideration of the effects exogenous administration of oxytocin in different situations has made it clear that oxytocin is *not* a direct elicitor of love. Indeed, there appears to be a significant interaction effect of oxytocin administration with social context, wherein oxytocin can lead to loving behaviors in certain situations, and antisocial behaviors in others. Other characteristics of social context may have similarly significant interactions with neuroscientifically identified variables of importance with regards to love; integrating an understanding of these characteristics into future research will be of utmost importance.

An illustration of the promise of blending the behavioral and neuroscience approaches

New ways to operationalize love

We suggest considering one social psychological construct – that of communal responsiveness (Clark & Monin 2006, Clark & Lemay 2010, Clark & Mills 2012, Reis & Clark in press) – as one that may fruitfully guide some neuroscience studies of love, as well as one that might itself benefit from neuroscientific study.

Communal responsiveness can be most simply defined as the assumption of responsibility for promoting a partner's welfare and, in mutual relationships, non-contingently seeking and accepting partner's support of one's own welfare. This is a type of love that may appear in high quality friendships, family relationships and romantic relationships, but that cannot be identified in those lay terms, because not all friendships, familial relationships, and romantic relationships will be characterized by high levels of communal responsiveness. It can be asymmetrical, involving one individual assuming responsibility for another's welfare without reciprocation (as in a mother-infant relationships), or symmetrical, as in most friendships and romantic relationships. The sense of

love in these relationships emerges both from being cared, for being caring. It is associated with feelings of security, trust, feeling cared for and feeling caring (see Reis, et al. 2004; Reis & Clark in press). It has a long history of study in social psychology (Clark & Mills 1979, 1993, 2012; Mills & Clark 1982; Reis et al. 2004), and corresponds well with lay use of the term "close" as it modifies relationships (Mills et al. 2004).

People in successful communally responsive relationships do not track individual inputs into joint tasks (Clark 1984, Clark et al. 2011), but do track one another's needs (Clark et al. 1986), offer non-contingent support to one another (Clark et al. 1987), and expect and accept support given to them from the partner reacting to it with enhanced liking (Clark et al. 1998, Clark & Mills 1979), without indebted feelings, and with enhanced feelings of satisfaction (Clark et al. 2011). Importantly, communal relationships can also vary in what is called "communal strength" (Mills et al. 2004). We do not assume equal responsibility for all "close" others' welfare. Rather, we assume more responsibility for some people's welfare more so than for others and, in the event of conflicts, or limitations on our ability to provide care, will prioritize the needs of those higher in their communal hierarchies (Clark & Mills 2012). People also place themselves in their own hierarchies of responsibilities, and the needs of others' may be placed above their own, equal to their own, or below their own. Even among an individual's set of communal relationships might be stratified by strength as might a set of different people's romantic relationships or marriages.

Communal responsiveness is something that has been shown to be easiest for those with secure (non-anxious, non-avoidant) attachment styles, and those high in self-esteem and low in rejection sensitivity. It fits well with the concepts of companionate love (Walster et al. 1978) and friendship based love (Grote & Frieze 1994), but its nature has been fleshed out in more detail and it has been described, extensively, in terms of characteristic intra- and inter-personal processes (see Clark & Lemay 2010), including the expression of emotion, and the reaction to one's partner's expression of emotions (Clark et al. 2001, Clark & Finkel 2005a).

Communal responsiveness – a characteristic of close relationships, and potential way to identify them – is evident in the expression of emotion, and the reaction to others' expression of emotion, because such expression (of, for example, fear, sadness, anger, or happiness) is one way in which individuals are able to express their needs and desires (the responsiveness to which characterizes communal relationships) (Fridlund 1992, Jones et al. 1991, Levenson 1994, Miller & Leary 1992). Fear, for example, may signal that a person needs support in escaping or eliminating a danger, or comfort, which may allow him or her to respond most effectively to that danger. Sadness may suggest sympathy or support in repairing or replacing something would be welcome. Happiness may be a cue that whatever one is doing is right or that one should celebrate for and with another person. Thus, we would expect that a person desiring responsiveness should express his or her emotions to a partner, and the partner should attend and respond (Clark et al. 1987). This, in turn, ought to enhance felt intimacy and relationship growth (Graham et al. 2008), two primary characteristics of the relationship state that both behavioral science and neuroscience are trying to measure.

It is also the case, however, that our expression of emotions can be, and often are, ignored or reacted to negatively (Clark et al. 1987, Yoo et al. 2011). Emotion expression can also cause he or she to whom the expression was directed to report decreased feelings of liking the expressor when a close relationship is not desired (Clark & Taraban 1991). This danger is especially notable in light of the fact that the very act of revealing needs and desires leaves the expressor vulnerable and open to exploitation. It is thus unsurprising that, early in development, people acquire the ability to suppress expressions of emotions when in the company of those who do not care for them, and/or who might harm them, and that people are more willing to express emotions in relationships characterized by high than by low communal strength (Clark & Finkel 2005b). The overall volume of emotion expression, responsiveness to it notwithstanding, may then have utility as a measureable (to some degree implicit) measure of the intimacy of a relationship.

Reactivity may also be a marker of utility. Reactivity to expressed sadness (relative to neutral expressions by the same person) ought to be greater and different in nature to partners than to others showing evidence of desired approach toward others and, importantly, a lack of indices of self-protection. The nature of reactivity should be distinct not just within person processing of communal partners' sad faces versus other sad faces, but also between participants' with strong communal relationships with partners versus those with weak communal relationships with partners and between those with secure attachment styles and those with high levels of attachment relationship anxiety or attachment related avoidance.

How might this be operationalized, so that it might be useful in an experimental setting? One way might be for researchers to recruit people in ongoing relationships with others, and expose them to film of their partners gazing at them with a variety of facial expressions. Similar photos of other individuals with the same expressions might be utilized as well. The nature of reactions to these expressions ought to capture much about love, and do so with fewer demand characteristics than if a researcher were to recruit participants upon the basis of being "madly" in love, or to ask in-depth questions about the quality of the relationship in an interview setting, as a way of quantifying intimacy. The definition of love set forth above, together with existing studies of responsiveness to others' emotions indicative of need, thus suggests ways to elicit feelings of love for a partner, defined in process terms, in a laboratory setting, and avoiding the issues outlined earlier in this paper with the existing measures of love.

How new operationalizations could be applied in neuroscience

A consideration of existing work on responsiveness and its links to reacting to others' emotions

not only suggest new studies, but also new ways to think about extant neuroscience data. For instance, in a recent neuropsychological article on people's reactions to another others' emotional facial expressions (Christinzio et al. 2010), participants viewed pictures of faces depicting either anger or fear. In that study, the authors crossed their manipulation of expressed emotion with a manipulation of the direction of emotional target person's gaze, such that the target gazed either directly at the participant perceivers, or away from them. They posited that a fear gaze would be most self-relevant (and hence in normal, healthy participants, generate greater amygdala activation) when it was directed away from, rather than towards, the participant perceiver. The reasoning behind this hypothesis was that another's fear of the environment (in which both the target and the perceiver exist) indicates that both may be in danger, but another's fear of the *participant* is not a signal of danger *for that participant*. Put another way, fear by a target who is gazing at the perceiver is not as relevant to the perceiver's welfare as fear by a target who is looking elsewhere, which may indicate a danger that the participant him or herself has not yet seen. For anger, Christinzio et al. suggested that the opposite pattern would be obtained. Thus, an expression of anger is most self-relevant when directed toward the observer because it signals danger to the self, but when directed elsewhere, it is less relevant to the perceiver's welfare. Based on this they predicted, and found (in normal, non-brain damaged, participants), greater amygdala activation in response to the fear faces directed away from (rather than towards) the participant, and in response to anger directed towards the participant (rather than away) conditions. This makes perfect sense but – critically – only for processing information about strangers.

As humans, we are, however, social creatures. A significant proportion of our interactions are with other people, and a significant proportion of those interactions are with people with whom we have some type of relationships, however minimal. Furthermore, it is these interactions – within individuals with whom we have some type of relationship – that are likely of greatest importance to us. Would one get the same sort of results reported by Cristinzio et al. if the viewer had some sort of relationship with the target person, real or imagined? What if he or she had an intimate relationship with the target, in the sense of feeling responsible for that target's welfare? We think not, in both cases, and behavioral research backs us up. When one cares deeply for a person's welfare, and that person gazes directly at you with a fearful expression on his or her face, that fear becomes very self-relevant because *you* are responsible for that other person's welfare. (Think about a mother whose very fearful child is looking right at her. That fear is very relevant to child, and by virtue of their relationship, to her). Amygdala activation should jump, perhaps as much as it does when the gaze on the same face is diverted. Indeed, we suggest, activation to a fearful or sad face gazing right at you (relative to one gazing away) might thus be a pretty good measure of how much a person cares about the owner of that face. Relational context thus would appear to affect perceptual processes, and this needs to be taken into account, if we are using these processes as part of an investigation into, for example, what makes love different from other types of social relationships, and/or different from a context in which there is no relationship at all.

Analogous points might be made in connection with the finding in the neuroscience literature that signals of another's fear causes the inhibition of motor activation within the observer (Sagaspe et al. 2011). We suspect not, if the other is someone about whom one cares deeply. Instead, such a person's fear should cause you to jump into action and comfort the person , or to remove the reason for his or her fear; indeed your doing so could be considered a sign of the existence of responsive love. The same point might be made with Christinzio et al.'s (2010) findings relating to reactivity to faces depicting anger: Whereas it is true, from an individualistic point of view, that an angry person gazing at you is more self-relevant than one gazing away, relevance changes if one shares a close relationship with the angry person. Anger will remain relevant if the person is away from you, though instead of fear of harm, one might become motivated to right the wrong and care for the angry person (cf. Yoo et al. 2011). One might, for example, wish to join in the anger, or address the problem that caused the anger.

Neuroscience studies will also, of course, advance more traditional studies of relationships as well. In this regard it was informative to us, as researchers interested in how responsive love shapes the experience and expression of emotion, to consider the results of imaging studies recently reported by Suslow, Kugel and their colleagues (Suslow et al. 2009, 2010). These researchers examined links between attachment related avoidance and brain activation in response to a target person's (masked) emotional face. One of their findings was that avoidance was inversely related to activation of the primary somatosensory cortex, and they further noted that this area is involved in the mimicking of social partners, as well as the simulation of the experiences of those other partners, perhaps for the purpose of understanding them. For those of us interested in responding supportively to partner emotions indicative of needs, this is very interesting. We know well that avoidant people do not provide as much support to others as do people low in avoidance, and that they do not respond to others' emotions with support to the same extent to which secure individuals do (Simpson et al. 1992). Yet social psychologists had not come up with the specific idea that avoidant people might be blocking (maybe even unconsciously) the sorts of mimicry of partners – and thus the simulation of partner feelings – that might be the foundation for understanding those partners' feelings, and thus that might elicit care. This neuroscience work here suggests that possible mediating mechanism, and future work in the same domain will no doubt continue to be just as informative.

Concluding comments

We began by noting that neuroscientists are actively seeking the nature of love with some success. We then asked if lessons from traditional relationship science might support and promote that endeavor. We

have made some broad suggestions here, and have included one illustration of how work on a particular question in which we ourselves are interested - the social functions of expressed emotion in close relationships - might help to advance this neuroscientific endeavor, as well as be itself advanced by broader collaboration between relationship researchers. We do believe collaboration between traditional relationship scientists and neuroscientists holds tremendous promise and hope to see the promise fulfilled in future studies.

References

Aron A, Fisher H, Mashek DJ, Strong G, Li H, & Brown LL (2005). Reward motivation and emotion systems associated with early-stage intense romantic love. *Journal of Neurophysiology* 94, 327-337.

Bartels A & Zeki S (2000). The neural basis of romantic love *Neuroreport* 11, 3829.

Bartels A & Zeki S (2004). The neural correlates of maternal and romantic love. *NeuroImage* 21, 3, 1155-66.

Bartz J, Simeon D, Hamilton H, Kim S, Crystal S, Brown A, Cicens V & Hollender E (2011). Oxytocin can hinder trust and cooperation in borderline personality disorder. *Social Cognitive and Affective Neuroscience* 6, 556-563.

Beauregard M, Courtemanche J, Paquestt VS & St Pierre EL (2009). The neural basis of unconditional love. *Psychiatric Research* 172, 93-98.

Beck LA & Clark MS (2010). What constitutes a healthy communal relationship and why relationship stage matters. *Journal of Family Theory & Review* 2, 299-315.

Berscheid E & Walster E (1974). A little bit about love. In T Huston (Ed) *Foundations of interpersonal attraction*, pp. 355-381. Academic Press, New York.

Baumeister RF, Stillwell AM & Heatherton TF (1994). Guilt: An interpersonal approach. *Psychological Bulletin* 115, 243-267.

Baumeister RF, Wotman SR & Stillwell AM (1993). Unrequited love: On heartbreak anger guilt scriptlessness and humiliation. *Journal of Personality and Social Psychology* 64, 377-394.

Bianchi-Demicheli F, Grafton ST & Ortigue S (2006). The power of love on the human brain. *Social neuroscience* 1, 90-103.

Beck LA & Clark MS (in press). What constitutes a healthy communal marriage and why relationship stage matters. *Journal of Family Theory & Review.*

Brennan KA, Clark CL & Shaver PR (1998). Self-report measurement of adult attachment: An integrative overview. In JA Simpson & WS Rholes (Eds) *Attachment theory and close relationships*, pp. 46-76. Guilford Press, New York.

Cheng Y, Chen C, Lin C-P, Chou KI & Decety J (2010). Love hurts: An fMRI study. *Neuroimage* 51, 923-929.

Clark MS (1984). Record keeping in two types of relationships. *Journal of Personality and Social Psychology* 47, 549-557.

Clark MS (2003). Two types of relationship closeness and their influence on people's emotional lives, pp. 824-838. In RJ Davidson, KR Scherer & HH Goldsmith (Eds) *Handbook of Affective Sciences*. Oxford University Press Inc, New York.

Clark MS & Beck LA (2011). Initiating and evaluating close relationships: A task central to emerging adults. In FD Fincham & M Cui (Eds) *Romantic relationships in emerging adulthood*, pp. 190-212. Cambridge University Press, New York.

Clark MS & Brissette I (2000). Relationship beliefs and emotion: Reciprocal effects, pp. 212-240. In NH Frijda, ASR Manstead & S Bem (Eds) *Emotions and beliefs: How feelings influence thoughts*. Cambridge University Press, Paris.

Clark MS, Dubash P & Mills J (1998). Interest in another's consideration of one's needs in communal and exchange relationships. *Journal of Experimental Social Psychology* 34, 246-264.

Clark MS & Finkel EJ (2005a). Does expressing emotion promote well-being? It depends on relationship context. In LA Tiedens and CW Leach (Eds) *The Social Life of Emotions*, pp. 105-126. Cambridge University Press, New York.

Clark MS & Finkel EJ (2005b). Willingness to express emotion: The impact of relationship type communal orientation and their interaction. *Personal Relationships* 12, 169-180.

Clark MS, Fitness J & Brissette I (2001). Understanding peoples' perceptions of relationships is crucial to understanding their emotional lives, pp. 253-278. In G Fletcher & MS Clark (Eds) *Interpersonal Processes,* Volume 3 of the Blackwell Handbook of Social Psychology. Blackwell, London.

Clark MS & Lemay EP (2010). Close relationships. In ST Fiske, DT Gilbert & L Gardner (Eds) *Handbook of social psychology,* Volume 2 (5th ed), pp. 898-940. John Wiley & Sons, Inc, Hoboken, NJ.

Clark MS, Lemay EP, Graham SM, Pataki SP & Finkel EJ (2010). Ways of giving benefits in marriage: Norm use relationship satisfaction and attachment-related variability. *Psychological Science* 21, 944-951.

Clark MS & Mills J (1979). Interpersonal attraction in exchange and communal relationships. *Journal of Personality and Social Psychology* 37, *1*2-24.

Clark MS & Mills J (1993). The difference between communal and exchange relationships: What it is and is not. *Personality and Social Psychology Bulletin* 684-691.

Clark MS & Mills J (2012). Communal (and exchange). Relationships. In PAM Van Lange, AW Kruglanski, ET Higgins (Eds) *Handbook of Theories of Social Psychology*. Sage Publications, Thousand Oaks, Ca.

Clark MS, Mills J & Corcoran D (1989). Keeping track of needs and inputs of friends and strangers. *Personality and Social Psychology Bulletin* 15, 533-542.

Clark MS, Ouellette R, Powell M & Milberg S (1987). Recipient's mood relationship type and helping. *Journal of Personality and Social Psychology* 53, 94-103.

Clark MS & Monin JK (2006). Giving and receiving communal responsiveness as love. In RJ Sternberg & K Weis (Eds) *The New Psychology of Love*. Yale University Press, New Haven, Ct.

Clark MS & Taraban CB (1991). Reactions to and willingness to express emotion in two types of relationships. *Journal of Experimental Social Psychology* 27, 324-336.

Christinzio C, N'Diaye K, Seeck M, Vuilleumier P & Sander D (2010). Integration of gaze direction and facial expression in patients with unilateral amygdala damage. *Brain: A Journal of Neurology* 133, 248-261.

Darwell S (2006). *The Second-Person Standpoint: Morality Respect and Accountability*. Harvard University Press, Cambridge, Mass.

Downey G & Feldman SI (1996). Implications of rejection sensitivity for intimate relationships. *Journal of Personality and Social Psychology* 70, 1327-1343.

Dutton DG & Aron AP (1974). Some evidence for heightened sexual attraction under conditions of high anxiety. *Journal of Personality and Social Psychology* 30, 510-517.

Fehr B (1988). Prototype analysis of the concepts of love and commitment. *Journal of Personality and Social Psychology* 55, 557-579.

Fisher H (2004). *Why we love?* Henry Holt, New York.

Fisher H, Aron A & Brown LL (2005). Romantic love: an fMRI study of a neural mechanism for mate choice. *The Journal of comparative neurology* 493, 58-62.

Fridlund A (1992). The behavioral ecology and sociality of human faces In MS Clark (Ed) *Emotion*, pp. 90-121. Sage Publications, Thousand Oaks, CA.

Gagne F & Lydon J (2001). Mindset and Relationship illusions:

The moderating effects of domain specificity and relationship commitment. *Personality and Social Psychology Bulletin* 27, 1144-1155.
Gonzaga GC, Turner R, Keltner D, Campos B & Altemus M (2006). Romantic love and sexual desire in close relationships. *Emotion* 6, 163-79. doi:10.1037/1528-3542.6.2.163.
Graham SM, Huang J, Clark MS & Helgeson V (2008). The positives of negative emotion: Willingness to express negative emotions promotes relationships. Personality and *Social Psychology Bulletin* 34, 394-406.
Grote NK & Frieze IH (1994). The measurement of friendship-based love in intimate relationships. *Personal Relationships* 1, 275-300.
Hatfield E (1988). Passionate and companionate love. In RJ Sternberg and ML Barnes (Eds) *The Psychology of Love*, 1st edition, pp. 191-217. Yale University Press, New Havenn Ct.
Hatfield E & Sprecher S (1986). Measuring passionate love in intimate relations. *Journal of Adolescence* 9, 383-410.
Hatfield E & Rapson RL (1987). Passionate love/Sexual desire: Can the same paradigm explain both? *Archives of Sexual Behavior* 16, 259-278.
Hatfield E & Rapson RL (2008). The neuropsychology of passionate love. In E Cuyler & M Ackhard (Eds) *Psychology of Relationships*, pp. 1-26. Nova Science Publishers, Inc. New York.
Hendrick C & Hendrick SS (1986). A theory and method of love. *Journal of Personality and Social Psychology* 50, 393-402.
Huh J, Park K, Hwang IS, Jung S, Kim HJ & Chung TW (2008). Brain activation of sexual arousal with olfactory stimuli in men: A preliminary study using function MRI. *Journal of Sexual Medicine* 5, 619-625.
Jones SS, Collins K & Hong H (1991). An audience effect on smile production in 10-month-old infants. *Psychological Science* 2, 45-49.
Karremans JC, Haslenfeld DJ, Van Dillen LF & Van Lange PAM (2011). Secure attachment partners attenuate neural responses to social exclusion: An FMRI investigation. *International Journal of Psychophysiology* 81, 44-50.
Kelley HS, Holmes JG, Kerr NL, Reis HT, Rusbult CE, Van Lange PAM (2003). *An Atlas of Interpersonal Situations*. Cambridge University Press, Cambridge England.
Kunstman JW & Maner JK (2011). Sexual overperception: Power mating motives and biases in social judgment. *Journal of Personality and Social Psychology* 100, 282-294.
Laurenceau J, Riverra LM, Schaffer AR & Pietromonaco PR (1998). Intimacy as an interpersonal process: The importance of self-disclosure partner disclosure and perceived partner responsiveness in interpersonal exchanges. *Journal of Personality and Social Psychology* 74, 1238-1251.
Lee JA (1977). A typology of styles of loving. *Personality and Social Psychology Bulletin* 3.
Lee JA (1988). Love-styles. In RJ Sternberg and ML Barnes (Eds) *The Psychology of Love* 1st edition, pp. 38-67. Yale University Press, New Haven Ct.
Lemay EP & Clark MS (2008). How the head liberates the heart: projection of communal responsiveness guides relationship promotion. *Journal of Personality and Social Psychology* 94, 647-671.
Lemay EP, Clark MS & Feeney BC (2007). Projection of responsiveness to needs and the construction of satisfying communal relationships. *Journal of Personality and Social Psychology* 92, 834-853.
Levenson R (1994). What is the function of emotions? In P Ekman & RJ Davidson (Eds) *The nature of emotion: Fundamental questions*, pp. 97-177. Oxford University Press, New York, NY.
Liebowitz MR (1983). *The chemistry of love.* Little Brown and Co, Boston.
Maner JK, Rouby DA & Gonzaga GC (2008). Automatic inattention to attractive alternatives: The evolved psychology of relationship maintenance. *Evolution and Human Behavior* 29, 343-349.
Marazziti D (2005). The neurobiology of love. *Current Psychiatry Reviews* 1, 331-335.
Marazziti DA, Akiskal HS, Rossi A & Cassano GB (1999). Alteration of the platelet serotonin transporter in romantic love. *Psychological Medicine* 29, 741-745.
Marazziti D & Canele D (2004). Hormonal changes when falling in love. *Psychoneuroendrocrinology* 29, 931-936.
Mikulincer M & Shaver PR (2007). *Attachment in adulthood: Structure dynamics and Change*. Guilford Press, New York.
Miller RS & Leary MR (1992). Emotion and social behavior. In M S Clark (Ed) *Emotion and social behavior*, pp. 202-221. Sage Publishers, Thousand Oaks, CA.
Miller SL & Maner JK (2009). Ovulations as a male mating prime: Subtle signs of women's fertility influence men's mating cognition and behavior. *Journal of Personality and Social Psychology* 100, 295-308.
Miller SL & Maner JK (in press). Scent of a woman: Male testosterone responses to female olfactory ovulation cues. *Psychological Science*.
Miller RS (1992). The nature and severity of self reported embarrassing circumstances. *Personality and Social Psychology Bulletin* 18, 190-198.
Mills J & Clark MS (1982). Exchange and communal relationships. In L Wheeler (Ed) *Review of Personality and Social Psychology*, Vol. 3, pp. 121-144. Sage, Beverly Hills, CA.
Mills J, Clark MS, Ford T & Johnson M (2004). Measurement of communal strength. *Personal Relationships* 11, 213-230.
Mikulincer M & Shaver PR (2007). *Attachment in adulthood: Structure dynamics and change*. Guilford Press, New York.
Monin JK, Matire LM, Schulz R & Clark MS (2009). Willingness to express emotions to caregiving spouses. *Emotion* 9, 101-106.
Monin JK, Matire LM, Schulz R & Clark MS (2009). Willingness to express emotions to caregiving spouses. *Emotion* 9, 101-106.
Monin JK, Clark MS & Lemay EP (2008). Communal responsiveness in relationships with female versus male family members. *Sex Roles* 59, 176-188.
Monin JK, Schulz R, Feeney BC & Clark TB (2010). Attachment insecurity and perceived partner suffering as predictors of caregiver distress. *Journal of Experimental Social Psychology* 46, 1143-1147.
Murray SL, Holmes JG & Collins NL (2006). Optimizing assurance: The risk regulation system in relationships. *Psychological Bulletin* 641-666.
Murray SL & Holmes JG (2011). *Interdependent minds: The dynamics of close Relationships*. Guilford Press, New York.
Nariuchi M, Kikuchi Y & Senoo A (2008). The functional neuroanatomy of maternal love: Mother's responsiveness to infant's attachment behaviors. *Biological Psychiatry* 63, 415-423.
Ortigue S, Bianchi-Demicheli F, de C Hamilton A & Grafton S (2007). The neural basis of love as a subliminal prime: An event-related functional magnetic resonance imaging study. *Journal of Cognitive Neuroscience* 19, 1218-1230.
Panksepp J (1992). A critical role for "affective neuroscience" in resolving what is basic about basic emotions. *Psychological Review* 99, 554-60.
Reis HT & Aron A (2008). Love: What is it why does it matter and how does it operate? *Perspectives on Psychological Science* 3, 80-86.
Reis H, Clark MS & Holmes J (2004). Perceived partner responsiveness as an organizing construct in the study of intimacy and closeness In DJ Mashek & AP Aron (Eds) *The Handbook of loseness and Intimacy*, pp. 201-225. Lawrence Erlbaum Associates, Mahwah, NJ.
Reis HT & Clark MS (in press). Responsiveness In J Simpson & L Campbell (Eds) *Handbook of Close Relationships*. Oxford University Press, Oxford England.

Reis HT & Shaver P (1988). Intimacy as an interpersonal process. In S Duck DF, Hay SE Hobfoll & W Ickes (Eds) *Handbook of personal relationships: Theory research and interventions*, pp. 367-389. John Wiley & Sons.

Reis HT & Patrick BC (1996). Attachment and intimacy: Component processes. In ET Higgins and AW Kruglanski (Eds) *Social Psychology: Handbook of Basic Principles*, pp. 523-563. Guilford Press, New York.

Roberts RC (2009). Emotional consciousness and personal relationships. *Emotion Review* 1, 281-288.

Rubenstein AJ, Langlois JH & Roggman LA (2002). What makes a face attractive and why: The role of averageness in defining facial beauty. In G Rhodes & LA Zebrowitz (Eds) *Facial attractiveness : Evolutionary cognitive and social perspectives*, pp. 1-33. Ablex, Westport, Ct.

Rubin Z (1970). Measurement of romantic love. *Journal of Personality and Social Psychology* 16, 265-273.

Rubin Z (1973). *Liking and loving: An invitation to social psychology*. Holt Rinehart & Winston.

Rusbult CE & Arriaga XB (1997). Interdependence theory In S Duck (Ed) *Handbook of personal relations: Theory research and interventions*, pp. 221-250. John Wiley & Sons, Hoboken, N J.

Rusbult CE, Olsen N, David JL & Hannon MA (2001). Commitment and relationship maintenance mechanisms. In JH Harvey & AE Wenzel (Eds) *Close romantic relationships: Maintenance and enhancement*, pp. 87-113. Erlbaum, Mahwah, NJ.

Sangrador JL & Yela C (2000). What is beautiful is loved: Physical attractiveness in love relationships in a representative sample. *Social Behavior and Personality: An international Journal* 28, 207-218.

Shaver PR & Mikulincer M (2012). Attachment theory. In PAM Van Lange, AW Kruglanski & ET Higgins (Eds) *Handbook of Theories of Social Psychology*, Vol 2, pp. 160-179. Sage Publications, Thousand Oaks, Ca.

Simpson J & Campbell L (Eds). *Handbook of Close Relationships*. Oxford University Press, Oxford, England.

Simpson JA, Rholes WS & Nelligan JS (1992). Support seeking and support giving within couples in anxiety-provoking situations: The role of attachment styles. *Journal of Personality and Social Psychology* 62, 434-446.

Sternberg RJ (1997). Construct validation of a triangular love scale. *European Journal of Social Psychology* 27, 313-337.

Suslow T, Kugel H, Rausch AV, Dannlowski U, Bauer J, Konrad C, Arolt V, Hendel W & Ohrmann P (2009). Attachment avoidance modulates neural response to masked facial emotion. *Human Brain Imaging* 30, 3553-3562.

Suslow T, Dannkiwsjum YM, Arikutm V & Ohrmann P (2010). Adult attachment avoidance and automatic affective response to sad facial Expressions. *Australian Journal of Psychology* 62, 181-187.

Tice DM & Baumeister RG (2001). The primacy of the interpersonal self. In Sedikides CE & Brewer MB (20001). *Individual self relational self and collective self*. Psychological Press, New York.

Walster E, Walster GW & Berscheid E (1978). *Equity: Theory and research*. Allyn & Bacon, Boston.

White GL, Fishbein S & Rutstein J (1981). Passionate love: The misattribution of arousal. *Journal of Personality and Social Psychology* 41, 56-62.

Xu X, Aron A, Brown L, Cao G, Feng T & Weng X (2011). Reward and motivation systems: A brain mapping study of early-stage intense romantic love in Chinese participants. *Human Brain Mapping* 32, 249-257.

Yoo S, Clark MS, Lemay EP, Salovey P & Monin J (2011). Responding to partners' expression of anger: The role of communal Motivation. *Personality and Social Psychology Bulletin in press*.

Young LJ (2009). Love: Neuroscience reveals all. *Nature* 457, 148-148.