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HRV Reactivity and New Romance: Cause or Consequence?

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Abstract

This study explored two competing hypotheses explaining the association of heart rate variability (HRV) and romantic relationships. HRV refers to the variation between successive heartbeats and is considered to be a noninvasive index of the social engagement system. Recent cross-sectional research has shown differences in HRV reactivity (the difference between HRV during the presentation of positive and negative stimuli) between single and newly coupled individuals. Two opposing explanations for this association were hypothesized. First, beginning a romantic relationship may decrease HRV reactivity through increased activation of the social engagement system during courting. Alternatively, this association could be explained by individuals with initially lower HRV reactivity being more likely to form romantic relationships. In the present study, single female undergraduate students were presented with film clips of various valences while having their cardiac activity monitored. These participants then returned for follow-up either when they had begun a romantic relationship, or at the end of the 6-month observation period if they remained uncoupled. Moderating influences of body mass index (BMI), self-esteem, attachment, and emotional distress were assessed. Results revealed single and coupled participants were comparable in terms of their HRV reactivity at follow-up; neither group showed a significant decline in HRV during the negative film clip. Further, HRV was not systematically affected by a change in relationship status from single to newly coupled. However, lower HRV reactivity was predictive of coupling for low BMI women while the reverse was true for high BMI women. This interaction may be the result of differing success rates of various mating strategies for low and high BMI women. Results support the hypothesis that HRV reactivity, along with BMI, can predict the formation of romantic relationships.

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HRV Reactivity and New Romance: Cause or Consequence?

Researchers from diverse fields have only recently discovered the importance of heart rate variability (HRV) in physical and psychological research. HRV refers to the variation between successive heartbeats and is extracted through electrocardiography (ECG). Interbeat variability occurs as a result of the heart's responsiveness to its environment. A healthy heart will respond more often to environmental cues and will return to baseline more quickly, resulting in higher variability. The correlates of HRV are numerous. For example, low resting HRV has been repeatedly linked to emotional dysregulation, increased risk of all-cause mortality, and physiological stress (Appelhans & Luecken, 2006; Porges, 1995, 2003; Thayer & Lane, 2007, 2009).

While a wide range of physiological factors are responsible for regulating heart function, few play as significant a role as the autonomic nervous system (ANS). The ANS regulates the vital organs of the body and has two major branches—the sympathetic nervous system (SNS), associated with energy mobilization, and the parasympathetic nervous system (PNS), associated with vegetative and restorative functions (Thayer & Sternberg, 2006). The heart is dually stimulated by the ANS. Increases in sympathetic activity are associated with increased heart rate and shortened interbeat intervals. Conversely, increases in parasympathetic activity are associated with decreased heart rate and lengthened interbeat intervals. Typically, the greater the average length of the interbeat interval, the greater the variability (Thayer, Åhs, Fredrikson, Sollers, & Wager, 2012).

Parasympathetic innervation of the heart is controlled by the vagus nerve with signals originating in the nucleus ambiguus. Signals from the vagus nerve slow heart rate by decreasing the firing rate of the sinoatrial node, the heart's natural pace-maker. When not under stress, heart rate is inhibited by the parasympathetic nervous system through the vagus resulting in low and variable heart rate (Watanabe & Schmidt, 2004). This inhibition has been demonstrated by experiments that pharmacologically blocked both cardiac vagal (the primary parasympathetic nerve) and sympathetic inputs. The researchers observed corresponding increases in heart rate (Jose & Collison, 1970). In this way, parasympathetic inputs serve as a ‘‘persistent brake to inhibit the metabolic potential” in mammals and the release of this brake results in the sympathetic fight or flight arousal (Porges, 1995, p. 306).

The influences of the SNS and PNS occur at different speeds which are most often expressed as a frequency in the standardized unit of hertz (Hz), calculated as the number of cycles per second (Applehans, 2006). Power spectral analysis allows for the measurement of HRV occurring at different frequencies. Parasympathetic components influence the entire frequency spectrum, whereas the sympathetic influences are restricted to the lower frequencies (Saul, 1990). Consequently, low frequency HRV (LF; below 0.15 Hz) represents a mixture of sympathetic and parasympathetic influences whereas high frequency HRV (HF; between .15-.40 Hz) represents primarily parasympathetic influences (Thayer et al., 2012). The HF and LF bands are typically measured in absolute values of power (ms^2). Thus, $HFms^2$ provides a noninvasive index of parasympathetic nervous system activity, specifically vagal activity (Porges et al., 1996; Thayer et al., 2012) and was used as the primary measure of HRV in the current study.

As described in Porges’ (1995, 1998) influential polyvagal theory, the vagus nerve has two branches: the evolutionary recent myelinated vagus and the older unmyelinated vagus. The unmyelinated vagus, also known as the dorsal vagal complex (DVC), is activated infrequently in mammals, but may be employed in response to a severe threat to promote behavioural strategies of sudden prolonged immobility or feigned death (Hofer, 1970; Porges, 1998). In mammals, the heart is regulated primarily by the myelinated vagus, also known as the ventral vagal complex

(VVC), which controls parasympathetic activity (Porges, 1997). The VVC provides tonic control over the heart and maintains a calm state to allow for social engagement and bonding (Porges, 1998).

In mammals, the VVC functions as a vagal brake. Under normal conditions, the vagus actively inhibits heart rate; however, under conditions of stress there is a transitory withdrawal of vagal stimulation to the heart, resulting in increased heart rate (Porges et al., 1996). This removal of the vagal break facilitates the expression of the sympathetic nervous system and promotes mobilization for fight-or-flight behaviours. Thus, the regulatory processes required for social engagement occur only in environments perceived as safe, when the sympathetic system is inactivated (Porges, 1998). As the VVC controls the social engagement system and vagal control of the heart, monitoring dynamic changes in HRV provides an efficient and noninvasive method of assessing the status of the social engagement system (Porges, 1998).

The functioning of the vagus and HRV have been linked to a myriad of phenomena. Correlates of low HRV include an array of serious and potentially deadly physical health problems (Masi, Hawkley, Rickett, & Cacioppo, 2007; Thayer & Lane, 2007), high body mass index (BMI), the inability to process and express emotions (Porges, 1995, 1997), stress and emotional distress experienced by the organism (Porges, 2003), and low self-esteem (Martens et al., 2010). While these correlates may first appear as quite discrepant, they can all be traced back to chronic activation of the sympathetic nervous system and perceived security from threat (Thayer et al., 2012).

HRV and Health Problems

As discussed previously, the two branches of the ANS keep the body in a state of dynamic balance. When the balance between these two branches is upset, as in the case where the sympathetic system is hyperactive and the parasympathetic system is hypoactive, the organism becomes less flexible and vulnerable to pathology (Brook & Julius, 2000; Thayer & Friedman, 2004; Thayer & Sternberg, 2006). Dominance of the sympathetic branch results in consistently high heart rate with little variability. Over long periods of time high heart rate can be physically draining on an individual leading to premature aging, disease, and eventually death (Thayer & Sternberg, 2006).

Stimulation of the vagus dampens sympathetic stress responses such as increases in norepinephrine (Levy, 1990) and cortisol (Bueno et al., 1989). When these stress responses are chronically activated, they may lead to or exacerbate cardiovascular problems (McEwen, 1998; Sapolsky, 1994). Research also suggests that vagal activation may decrease aspects of the inflammation response (Czura & Tracey, 2005) thereby reducing the risk of autoimmune diseases (Martens et al., 2010; McEwen, 1998; Sapolsky, 1994). Individuals with low resting HRV also show delayed cardiovascular, endocrine, and immune recovery from psychological stressors compared to those with higher levels of resting HRV (Weber et al., 2010). Overall, low resting HRV has been linked to serious physical health problems and poor health outcomes (Masi, Hawkley, Rickett, & Cacioppo, 2007; Thayer & Lane, 2007).

HRV and BMI

BMI, which often is linked to chronic health problems, has been found to be related to HRV. Several investigators have reported reduced HRV in obese subjects and subsequent HRV gains after weight loss (Karason, Mølgaard, Wikstrand, & Sjöström, 1999; Quilliot, Fluckiger, Zannad, Drouin, & Ziegler, 2001). Hirsch, Leibel, Mackintosh, and Aguirre (1991) monitored HRV in seven adults during weight change and found that a 10% increase in body weight was associated with a decline in HRV; however, they did not observe significant changes in HRV during weight loss, possibly because of the small sample size (Karason et al., 1999). Other studies have shown that BMI in the normal weight range is associated with optimal HRV; BMIs above 30 or below 19 were associated with the lowest HRV (Vallejo, Márquez, Borja-Aburto, Cárdenas, & Hermosillo, 2005). Based on polyvagal theory (Porges, 2003) individuals who exhibit higher resting HRV would also express more socially adaptive behaviors, and the opposite would be accompanied by more difficulties in social functioning (Porges, 2003a, 2003b; Dufey et al., 2011). Therefore, because of its association with HRV, higher BMI may be associated with interpersonal difficulties and less activation of the social engagement system.

HRV and Emotional Well-Being

Recent studies have linked emotional distress to higher levels of HRV reactivity. (Schneiderman, Zilberstein-Kra, Leckman, & Feldman, 2011). HRV reactivity is defined as vagal withdrawal in response to a negative stressor. Further, low levels of resting HRV have been found to be related to various pathological conditions of emotion dysregulation both in childhood (Porges, Doussard-Roosevelt, & Maita, 1994), and in adulthood (Beauchaine, 2001). High levels of anxiety, antisocial behaviour (Mezzacappa et al., 1997), and hostility (Vella & Friedman, 2007) have been linked to low levels of HRV and can be conceptualized as failures of emotional regulation. In addition, the ability to successfully regulate one's emotions has been linked to higher levels of HRV (Ingjaldsson et al., 2003; Smith et al., 2011) which may thereby facilitate further effective emotional regulation.

The ability to regulate emotion is closely related to the ability to flexibly respond to environmental stresses (Thayer et al., 2012). Individuals with greater emotion regulation ability have been shown to produce more context-appropriate emotional responses as indexed by behavioural and self-reported emotional and startle responses (Melzig, Weike, Hamm, & Thayer, 2009). Thus, individuals with higher resting levels of HRV appear more able to produce context-appropriate responses as well as react to, and recover from , environmental stressors more effectively (Thayer et al., 2012).

HRV and Perceptions of Threat and Safety

Emotions may serve to represent an individual's perception of environmental threats and their ability to respond to them (Frijda, 1986). Emotional dysregulation, as well as physical and mental illness, may then be a product of prolonged sympathetic activation due to a chronically threatening environment. In a recent meta-analysis, Thayer and colleagues (2012) described HRV's close relationship with perceptions of threat and safety. They asserted that these perceptions, and the associated actions that follow them, are important to the survival of the individual organism and ultimately to the survival of the species.

Thayer and colleagues (2012) illustrated their proposal with an example depicting a human walking in the woods centuries ago and seeing something coiled on the path ahead. The human must choose quickly between judging the path as safe and proceeding, or judging the object as a threat and changing course; the latter choice ensuring he or she will live to procreate another day (Thayer et al., 2012). Given the evolutionary advantage associated with the assumption of threat, fight-or-flight is the "default" response to uncertainty, novelty, and threat (Herry et al., 2007; Thayer & Lane, 2009). This default threat response may be related to the well-known 'negativity bias,' a phenomenon that describes the tendency to prioritize negative over positive information (Cacioppo et al., 1999). At one time, it may have been evolutionarily adaptive to prepare for the worst (Thayer & Lane, 2009). However, in our modern society living in a chronic state of preparedness eventually leads to general health decline (Chrousos & Kino, 2005; McEwen, 2001; Seeman et al., 2001).

Research supports the conclusion that higher resting levels of HRV are exhibited when we feel secure, and lower levels are exhibited when we feel insecure and vulnerable in our environments and relationships. Studies have found that higher HRV is predicted by a lack of anxiety-related disorders (Cohen et al., 1997), attachment anxiety (Diamond & Hicks, 2005), severe depressive symptoms (Chambers & Allen, 2002), and negative affect in response to threatening stimuli (Demaree, Robinson, Everhart, & Schmeichel, 2004; Martens et al., 2010). Further, HRV is associated with the neural structures that are involved in the appraisal of threat and safety (Thayer et al., 2012). Overall, HRV appears to provide a useful index of stress.

HRV and Self-Esteem

Emerging from literature on the link between security from threat and HRV, self-esteem was proposed as the mechanism responsible for increasing one's feelings of security (Martens et al., 2010). These authors believe that self-esteem increases feelings of security leading to an increase in HRV and the attenuation of SNS activity. Theories about the link between self-esteem and HRV can be traced back to self-affirmation theory (Sherman & Cohen, 2006). Self-affirmation theorists assert that an overarching sense of self-esteem provides greater flexibility in coping with threats and is associated with feelings of security. The theory conceives of self-esteem as a potential resource that can be used to compensate for threats to any given component of the self (Hobfoll, Nadler, & Leiberman, 1986; Taylor & Brown, 1988).

A good deal of research has supported the explanation offered by self-affirmation theory for the link between HRV and self-esteem. Evidence comes from experiments that manipulate self-esteem, during which increasing self-esteem was found to influence HRV (Martens et al., 2010). For example, increasing self-esteem by way of fictitious positive feedback about personality or intelligence resulted in reduced self-reported anxiety and sympathetic arousal in response to threat of electric shock (Greenberg et al., 1992) and attenuated heart rate in response to a public speaking stressor (Rector & Roger, 1997). Longitudinal studies also found that self-esteem covaried with resting HRV levels (Martens et al., 2010). Further, studies on related phenomena also lend support to the self-affirmation theory of self-esteem and HRV. That is, measures of state self-esteem correlate inversely with state threat-related emotions such as anxiety, hostility, and depression (Heatherton & Polivy, 1991), physiological fight or flight responses (Taylor, Lerner, Sherman, Sage, & McDowell, 2003), and stress in response to taxing life circumstances (Hobfoll & London, 1986). In sum, there is considerable evidence to support the view that higher levels of self-esteem provide security from threat and reduce threat-related responses. It follows that individuals with higher self-esteem will show higher resting HRV and less HRV attenuation in response to threat.

It is clear that HRV is a significant and multifaceted phenomenon. However, the varied correlates of HRV overlap considerably and can be traced back to stress and perceived security from threat. One potentially stressful period for many individuals is the courting period of a new romantic relationship and falling in love. The recent surge in psychophysiological love research has led to a convergence with HRV literature. Preliminary research is pointing to a link between romantic relationships and HRV.

Love and Romantic Relationship Research

The term love is most often associated with the romanticized notion that has been the subject of songs, poetry, and books for millennia. Love is a complex phenomenon with far-reaching consequences. From the euphoric, obsessive state of passionate love to the protection of a tenderhearted parent, love affects everyone. Of course, there is also a negative and potentially dangerous side of love. Relationship problems and unrequited love are often the catalyst for suicides, homicides, and emotional disorders such as anxiety and depression (Fisher, 1992). Therefore, love matters not only because it can improve our lives, but also because it is a major source of misery and human suffering (Berscheid & Reis, 1998; Reis & Aron, 2008).

Despite love's importance, psychologists have been slow to embrace love and romantic relationships as research topics. This slow start may be attributed the word love often being only loosely defined in the literature as researchers have yet to come to a consensus on an operational definition of love. The word love can be used to describe a wide range of feelings: a food preference, attachment to a parent, or passionate feelings towards a sexual partner. Reis and Aron (2008) defined love as "a desire to enter, maintain, or expand a close, connected, and ongoing relationship with another person or other entity" (p. 80). Within the overarching concept of love, Berscheid and Walster (1978) differentiated between passionate love, ''a state of intense longing for union with another,'' (p. 9) and companionate love, ''the affection we feel for those with whom our lives are deeply entwined,'' (p. 9). Considerable evidence supporting this distinction comes from psychometric analyses (e.g., factor analysis, multidimensional scaling, and prototype analysis), examinations of the behavioural and relationship consequences of different forms of romantic love, and biological studies (Reis and Aron, 2008).

This distinction is also represented in Sternberg's (1986) triangular theory of love, which has received substantial research support. According to the theory, love has three components: (a) intimacy, which encompasses the feelings of closeness and connectedness of loving relationships; (b) passion, which encompasses the drives that lead to romance and sexual desire; and (c) commitment, which encompasses the commitment to maintain that love (Sternberg, 1986). The amount of love one experiences depends on the absolute strength of these three components, and the kind of love one experiences depends on their strengths relative to each other (Sternberg, 1986). In total, Sternberg described eight types of love composed of these three components. Companionate love is conceptualized as a combination of intimacy and commitment and is essentially the same as the definition proposed by Berscheid and Walster. Sternberg's conceptualized romantic love as being derived from intimacy and passion and closely resembles Berscheid and Walster's (1978) concept of passionate love. The present study focuses on romantic or passionate love which characterizes the early stages of romantic relationships.

Researchers are beginning to narrow their definition of love, but in the absence of a consensus, many theorists have relied on prototypical models (Mervis & Rosch, 1981). The prototype method of classification represents a radical departure from traditional definition-based models. In prototypical models some members of a category are determined to be more central than others. These prototypical models have allowed researchers to determine the underlying dimensions of prototypical characteristics of love (Reis & Aron, 2008). Results from Fehr's (1988) study on a prototypical model of love suggest that trust and caring are considered highly prototypical of love, whereas uncertainty and butterflies in the stomach are more peripheral. Aron and Westbay (1996) found that intimacy, commitment, and passion appear to be underlying the prototypical model. Interestingly, these same three components make up Sternberg's triangular theory of love (Reis & Aron, 2008). The prototype analysis suggests that when individuals think about love they do not think in terms of sharply defined boundaries. Rather, they evaluate the degree to which each case possesses qualities essential to the prototype (Reis & Aron, 2008). Contemporary love researchers are beginning to form a cohesive picture of the processes involved in falling in love and maintaining romantic relationships, often from an evolutionary perspective (Reis & Aron, 2008).

The Evolutionary Perspective on Love and Romantic Relationships

Increasing evidence points to romantic love's permanence and cross-cultural similarity, although it was often rejected as a basis for marriage in the past. There are records of romantic love in all of the great literate civilizations of early historic times with each account displaying remarkable similarity in their descriptions of love (Hazan & Shaver, 1987; Mellen, 1981). Further, in a current-day analysis of 166 societies, romantic love was found across the globe (Jankowiak & Fischer, 1992), and over 90% of people in the world marry at least once during their lives (Buss, 1985). Thus love may have evolved as a commitment device to maintain relational bonds between mothers and fathers and facilitate mutual investment in offspring (Kirkpatrick, 1998; Mellen, 1981). Evidence for this theory is derived from the survival rates and later mating success of children, which are enhanced in offspring born and raised within pair bonds (Geary, 2000).

The process of entering into a potentially long-term mating relationship takes a great deal of time and effort and is disruptive to the individual's life. Consequently, passionate love is associated with many changes in cognition and emotion (Aron, Fisher, & Strong, 2006), motivating the individual to direct their attention and goal-directed behaviour toward a specific new partner (Berscheid & Ammazzalorso, 2001). For example, passionate love is frequently linked to difficulties focusing on other activities, an intense desire for closeness and contact, and idealized perceptions of the loved person (Reis & Aron, 2008). This interpretation explains why passion decreases in the early years of marriage once commitment has been established, even in satisfied couples. The decrease in passion allows the individuals to shift their resources to other priorities (Aron et al., 2006; Reis & Aron, 2008).

Romantic love can be considered to have two phases. The intense initial phase, which lasts up to 3 years, is colloquially known as the "honeymoon period", but is termed "romantic attraction" in the research community. This attraction may or may not progress to a second, more secure and comfortable phase of romantic love referred to as "romantic attachment," "companionate love," or "pair-bonding" (Bruce & Sanders, 2001; Fisher, 1995). In young adults, romantic episodes occur regularly and often do not lead to committed long-term relationships. Bruce and Sanders (2001) reported that 17- and 18-year-old university students averaged 1.45 romantic episodes per year and 93% of students reported at least one episode over the 2-year survey period. These romantic episodes were often short-lived with an average duration of 9 weeks if never reciprocated and 12 weeks if reciprocated.

Humans are equipped to engage in either short- or long-term mating strategies contingent on factors such as opportunity, personal mate value, sex ratio in the relevant mating pool, parental influences, cultural norms, and other features of social and personal context (Buss, 1994; Gagestand & Simpson, 2000; Schmitt et al., 2003). An extended courtship, heavy investment, pair-bonding, the emotion of passionate love, and the dedication of resources over a long temporal span are hallmarks of the long-term mating strategy (Schmitt, 2005). In stark contrast is the short-term mating strategy, which consists of fleeting sexual encounters such as a hookup or one-night stand. Brief affairs, prolonged romances, and other intermediate-term relationships fall between these two sets of mating behaviours. A pattern of intermediate-term relationships is most frequently exhibited in a university student population (Bruce & Sanders, 2001).

For young adults, these intermediate-term romantic episodes are unlikely to develop into an attachment phase thereby leading to a stable reproductive partnership (Bruce & Sanders, 2001). These attractions seem evolutionarily useless at first glance. However, attraction may enable individuals to learn to navigate the dating pool and eventually choose genetically superior mating partners (Fisher, 1998). From this perspective, it is reasonable to assume that the numerous short-lived attractions of adolescence and young adulthood act as a screening and learning process through which the ability to select desirable long-term mating characteristics is refined (Bruce & Sanders, 2001).

During this process individuals may learn to evaluate their own, and their potential partners', mate values. Mate value is defined as "the degree to which an individual would promote the reproductive success of another individual by mating with him or her" (Sugiyama, 2005, p. 296). Human mate value includes not only current fertility but also projected reproductive value across a lifespan. Thus, those who have higher reproductive value will have more offspring and will offer more opportunity to spread one's genes. The traits of those who have more offspring thus become indicators of mate value and individuals will be attracted to partners exhibiting these traits in order to ensure the survival of their own offspring (Sugiyama, 2005). Attachment, physical attractiveness, self-esteem, and well-being are all associated with mate value and mating strategy and are thus influential in determining which individuals will select and be successful in employing long-term mating strategies.

Love and Attachment

The constructs of romantic love and attachment are intertwined yet fundamentally different concepts that can occur independently. Attachment was originally conceptualized as a behavioural system that motivates infants to seek proximity to caregivers in times of distress. Based on remarkable similarities between human infants and other primate infants, Bowlby (1969, 1973, 1979; as cited in Hazan & Shaver, 1987) was led to consider the evolutionary significance of infant-caregiver attachment and referred to this system as the “attachment system”. Bowlby postulated that this system evolved to protect infants from danger by keeping them close to their mothers (1973; as cited in Hazan & Shaver, 1987). When an infant is healthy, alert, unafraid, and in the presence of its mother, it seems interested in exploring and mastering the environment and in establishing affiliative contact with other family and community members (Hazan & Shaver, 1987). Ainsworth, Blehar, Waters, and Wall (1978) delineated three styles or types of attachment: secure, anxious, and avoidant. The healthy infant as described above would be said to exhibit a secure attachment style. Infants in the anxious attachment category frequently exhibited the behaviours labelled “protest”, and the avoidant infants frequently exhibited the behaviours called “detachment”. Hazan and Shaver (1987) applied this categorization to the study of romantic relationships.

Following Bowlby’s line of research on childhood attachment, Hazan and Shaver’s (1987) article explored the possibility that adult romantic love is best conceptualized as an attachment process. In their seminal article, Hazan and Shaver suggested that attachment histories from infancy predict the experience of romantic love in adulthood. Hazan and Shaver had adults classify themselves and found that 56% of adults saw themselves as secure, whereas the other half split fairly evenly between the avoidant and anxious categories. These figures are remarkably similar to proportions reported in studies of infant-mother attachment (Campos et al., 1983; Hazan & Shaver, 1987). Depending on their group classification, participants’ descriptions of their relationships with their parents, their most important romantic love relationships, and the typical course of their love experiences varied predictably.

While Hazan and Shaver (1987) suggested that romantic love is an attachment process, they did not mean to imply equivalence between the two concepts. They described romantic love as a biological process designed by evolution to facilitate attachment between adult sexual partners who, at the time love evolved, were likely to parent children. The secure feelings that partners experience in each other's presence, the lonely feelings while they are apart, and the desire to be together after separations are hallmarks of the attachment system (Campbell & Ellis, 2005). Importantly, the hormone oxytocin plays a central role in the formation of attachment bonds between mother and infant (Hrdy, 1999), as well as between romantic partners (Carter, 1992), suggesting a mechanism that functions to promote attachments at all stages of life.

Several combinations of life history theory (Low, 1998) and attachment theory (Bowlby, 1969) have suggested that childhood experiences influence adult mating strategies (Belsky, 1999; Chisolm, 1996). According to Belsky et al (1991), early social experiences determine which reproductive strategy a child will later choose. Childhood exposure to high levels of stress (insensitive/inconsistent parenting, harsh physical environments, or economic hardship) typically results in the development of an insecure parent-child attachment and earlier physical maturation. These children are more likely to develop an "opportunistic" short-term mating strategy than their low-stress counterparts. On the other hand, more securely attached children develop a more "investing" long-term reproductive strategy in adulthood that is the most reproductively profitable in low stress environments with abundant resources and low mortality rates (Schmitt, 2005).

Support for these theories is cross-cultural. Schmitt and his colleagues (Schmitt, Alcalay, Allensworth, et al., 2004) conducted a study on over 17,000 participants from 56 nations. Their results indicated that insecure attachment styles were indeed strongly related to various indicators of familial stress, economic resources, mortality and fertility. Further, short-term mating was found to be related to insecure attachment across cultures. The avoidant form of insecure attachment was linked to short-term mating in men, and the anxious forms of insecure attachment being linked to short-term mating in women (Schmitt et al., 2004). These findings support the view that stressful environments cause insecure attachment and reliance on short-term mating strategies (Kirkpatrick, 1998).

Bowlby (1979; as cited in Hazan & Shaver, 1987) and Ainsworth and colleagues (1978) postulated distinct behavioural systems for the attachment, caregiving, and mating or reproductive systems. Adult romantic love results from the integration of these three systems, with the form of the integration being influenced by attachment style (Shaver, Hazan, & Bradshaw, 1988). Mating and partner attachment systems presumably operate more independently in nonmonogamous species and in individuals that engage in more short-term mating. Recent FMRI studies observed the somewhat overlapping nature of the neuronal circuitry mediating both attachment and romantic and maternal love. However, the neuronal pathways are also distinct (Stein & Vythilingum, 2009). Overall it appears that love and attachment are distinct but closely related concepts. For individuals with insecure attachment styles, short-term mating strategies prevail and they are less likely to form monogamous romantic relationships.

Love and Self-Esteem

While few studies have investigated the link between romantic love and self-esteem, this association could prove important in explaining love's wide-ranging effects on people's lives. The social barometer of self-esteem is associated with overall mate value and strategy (Kirpatrick, Waugh, Valencia, & Webster, 2002). North American men who score higher on self-esteem scales tend to engage in more short-term mating strategies (Baumeister & Tice, 2001). The reverse is typically true for women in modern nations whose high self-esteem makes them more likely to pursue monogamous, long-term mating strategies (Mikach, & Bailey, 1999).

In a series of four studies Dion and Dion (1975) found that self-esteem and defensiveness interacted to influence romantic love and the formation of long-term dating relationships. They found that participants high in self-esteem and low in defensiveness reported the most instances of romantic love. Results of this study are consistent with self-actualization theory, which predicts that high self-esteem individuals should be more receptive to romantic love and experience romantic love as more satisfying and fulfilling than those with lower self-esteem (Dion & Dion, 1975). However, the results for low self-esteem individuals do not support the assertion that individuals with lower self-esteem are less receptive to love.

In these studies individuals with low self-esteem indicated more instances of unrequited love, more intense romantic love experiences, higher scores on the love, liking, and trust scales, and more favourable evaluations of their romantic partners as compared to those with high self-esteem (Dion & Dion, 1975). Thus, instead of being less open to love, individuals with lower self-esteem may simply be less adept at engaging heterosexual partners in mutual love and have lower mate value. Indeed, there is considerable evidence indicating that individuals with low self-esteem are less skilled in interpersonal relations (Dion & Dion, 1975; Wylie, 1968).

Contemporary studies have found that individuals who fall in love also report higher than average levels of self-esteem just before falling in love (Aron, Paris, & Aron, 1995). Aron and colleagues also reported increases in both self-efficacy and self-esteem after falling in love (Aron et al., 1995). Hendrick and Hendrick's (1988) cross-sectional studies comparing individuals in love to those who were not found that individuals in love had higher self-esteem, but only in one of two samples. Overall, evidence points to a complicated link between love and self-esteem. It remains unclear whether individuals with higher self-esteem are more likely to fall in love or if beginning a romantic relationship reliably increases self-esteem.

Relationships and self-esteem may interact through several processes. As falling in love is typically a sought after experience in Western culture (Swidler, 1980), it is possible that simply attaining love will enhance self-esteem. Falling in mutual love also typically involves individuals discovering that they are liked (Aron et al., 1989) or even idealized by their partner (Reik, 1944), which may increase an individual's sense of self-worth (Greenberg, Pyszczynski, & Solomon, 1986). New relationships may also enhance perceived self-esteem and self-efficacy through a process of discovering the likes and dislikes of one's partner (Aron et al., 1995). Finally, higher self-esteem has been linked to interpersonal competence (Dion & Dion, 1975; Wylie, 1968). Therefore, higher self-esteem may facilitate meeting prospective mates and entering into a romantic relationship. Thus self-esteem may be a function of a person's self-perceived mate value.

Love and Physical Attractiveness

Human mate value assessments are the sum of a potential mate's phenotypic qualities of health, fertility, fecundity, age, intelligence, status, parenting skill, kindness, and willingness to invest in offspring (Buss 1989; Gangestad & Simpson, 2000; Symons, 1979, 1992, 1995; Thornhill & Gagestad, 1999). Some of these cues to phenotypic quality are physically observable, and thus constitute the mate's "physical attractiveness". A mate's physical attractiveness is more important to males as females' mate value is very closely linked to physiological conditions. Females, on the other hand, are more willing to trade off genetic quality and health for investment in offspring in their long-term mates (Sugiyama, 2005).

Female mate value is closely linked to age, health, and fertility (Buss, 1992; Symons, 1979, 1995). Physical traits that are considered attractive are indicative of these underlying reproductive advantages. For example, fluctuating asymmetry (FA) of both the face and body is negatively correlated with fitness-related measures of growth, survival, fecundity, intrasexual competitiveness, and mating success (Lagesen & Folstad, 1998; Moller, 2002; Thornhill, 1992). FA is influenced by mutational load and appears to be heritable (Mather, 195; Palmer & Stobeck, 1986; Watson & Thornhill, 1994). Thus symmetry is indicative of overall phenotypic quality.

Facial attractiveness provides important cues for recent and past health. For instance, skin quality provides a cue to both age and current and lifetime health (Symons, 1979, 1995). Insect bites, disease, infection and skin lesions and scars reduce skin quality and are associated with poorer health (Symons, 1995). Similarly, hair quality and length is significantly correlated with female attractiveness. Starvation and nutritional deficiencies cause loss of and damage to hair therefore providing an observable record of an individual's recent health and nutrition (Etcoff, 1999). Further, hair grows fastest among women around the ages of peak fertility (Etcoff, 1999) and environmental damage therefore has less time to accumulate. Thus healthy long hair can also be indicative of fertility. Diet is closely associated with health and overall fitness. Nutritional deficiencies can occur due to masticatory inefficiency, poor dentition, or dental disease. Therefore, strong, even, white teeth and good oral health can be used as an indicator of overall health (Symons, 1995; Walker, Sugiyama, & Chacon, 1998).

Bodily attractiveness, particularly BMI, exerts a large influence on overall ratings of the physical attractiveness of women. Gait and movement pattern during walking and dancing differ by age and health and are thus markers of these two reproductively important factors (Sugiyama, 2005. Females of mean height are the least likely to never have been coupled and have more marriages or long term mates than either their taller or shorter counterparts (Nettle, 2002). Waist to hip ratios (WHR) of 0.7 for females and 0.9 for males are deemed most attractive (Sugiyama, 2005). However, WHR tends to covary with BMI, which was found to be much more influential on a female's mate values.

Fertility, pregnancy, and lactation are supported by substantial fat stores (Frisch, 1990; Frish & McArthur, 1974). However, workload, resource availability, and health risks are ecologically variable, so the preferred level of body fat is adjusted depending on these environmental features (Sugiyama, 1996, 2004). An increased risk of local food shortages increases the desirability of increased body fat levels (Anderson et al., 1992). Kenyan and Ugandan men rated high-weight line drawings of females as significantly more attractive than either the British or Kenyan men living in Britain, although normal-weight female line drawings were preferred by all (Furnhm & Alibhai, 1983; Furnham & Bauma, 1994). Thus although body-weight preferences vary across cultures in predictable ways, obesity was not found to be the most attractive in any culture (Sugiyama, 2005). That being said, extreme thinness was also not rated as the most attractive (Tovee & Cornelissen, 2001).

In a series of studies BMI was reported to account for approximately 80% of the variance in female body attractiveness (Tovee & Cornelisson, 2001; Tovee et al., 2002). Tovee and Cornelisson (2001) had male and female British undergraduate students rate photos of real women in different BMI categories ranging from underweight at 15 to obese at more than 30. Men and women showed an indistinguishable preference for BMI of 19, with sharp declines in attractiveness ratings for both higher and lower BMI figures. In 2007 only 3.9% of Canadian females over the age of 18 had BMI under 18.5 (Stats Canada, 2007). Therefore the BMI of approximately 96% of Canadian women was higher than the ideal. Thus, in all but 4% of cases, higher BMI indicates lower mate value. Singh and Young (1995) found that low BMI, low WHR female figures with large breasts were judged the most attractive, feminine, healthy, and desirable for both short- and long-term relationships. Thus women exhibiting these physical traits, particularly lower BMI, have higher mate value and are more likely be successful in forming romantic relationships.

Love and Well-being

Romantic relationships are also associated with better psychological and physical health. The absence of social ties, the dissolution of romantic relationships, and unsatisfying relationships are associated with increased vulnerability to disease (Campbell & Ellis, 2005). For example, heart attack victims who live alone are more likely to have a recurring attack (Campbell & Ellis, 2005). Married men and women report more happiness than people who have never married, have separated, or have divorced (Myers & Diener, 1995). The happiest university students are those that feel satisfied with their love life. Finally, coupled individuals are less likely to experience depression and cope better with various stresses, including bereavement, rape, job loss, and illness than unhappily married or unmarried individuals (Myers, 1999). Overall it appears that humans are designed to respond positively when a long-term mate is secured and satisfying relationships endure (Campbell & Ellis, 2005).

Physiological Correlates of Love

Recently there have been significant scientific advances in the measurement of physiological processes which have made it possible to conduct research on the biological correlates of love. Research has focused on biological changes during the initial stages of falling in love. During this initial phase researchers have observed increased levels of plasma cortisol (Marazziti & Canale, 2004) and lower plasma serotonin (Marazziti, Akiskal, Rossi, & Cassano, 1999). Further, increased brain activation in areas involved in attachment- and reward-related processes were recorded for individuals who were newly and intensely in love (Aron et al., 2005; Bartels & Zeki, 2000, 2004). Certain of these brain areas are rich in dopamine, oxytocin, and vasopressin.

Oxytocin and vasopressin have been linked to attachment and monogamy. Seminal research on vole attachment has found that in the promiscuous montane vole there are less oxytocin and vasopressin receptors in reward areas, while in the monogamous prairie vole there are more receptors (Stein & Vythilingum, 2009; Young, Liu, & Wang, 2008). When these receptors are blocked in prairie voles, promiscuity ensues. Conversely, insertion of prairie vole vasopressin receptor gene into montane voles leads to exclusive mating (Stein & Vythilingum, 2009). This study highlights the importance of oxytocin, vasopressin, and related areas in the brain, in the formation of romantic bonds.

Functional imaging studies have allowed for the mapping of the brain under the influence of love (Beauregard, Courtemanche, Paquette & St-Pierre, 2009; Noriuchi, Kikuchi & Senoo, 2008; Ramasubbu et al., 2007). Both maternal and romantic love appear to be mediated by the anterior cingulate, medial insula, and caudate nucleus (Bartels & Zeki, 2004) and both may also involve the ventral tegmental area (Fisher, Aron & Brown, 2005; Stein & Vythilingum, 2009). Similarly, in longer-term relationships, the anterior cingulate and insular cortex are again involved (Aron et al., 2005; Bartels & Zeki, 2000; Stein & Vythilingum, 2009). Together this research points to observable hormonal and neuronal changes occurring in newly coupled individuals. Developments in these areas have fueled the surge in love research and have led researchers to extend their range in examining the physiological processes involved in passionate love and the formation of romantic relationships.

HRV and Romantic Relationships

Studies have shown that HRV is linked to both past and current relationships. General patterns of autonomic reactivity may be set in childhood as close maternal-infant contact functions to attenuate the infant's HRV reactivity to negative emotions (Feldman, Singer, & Zagoory, 2010). For instance, premature infants who received maternal-infant skin-to-skin contact showed less of a decrease in HRV in the presence of an emotional stressor 10 years later (Feldman, 2011). These findings suggest that a function of attachment relationships and love may be to increase autonomic regulation, and that patterns of reactivity can be set in infancy (Hofer, 1995).

While general patterns of autonomic reactivity may be influenced early in life by the formation of bonds in childhood, new adult romantic relationships are also theoretically linked to increased autonomic regulation. As described earlier, Porges (1995) lays out a comprehensive theory of autonomic functioning in his polyvagal theory. Porges (1998) described the association between the three components that regulate autonomic cardiac functioning and the beginning and maintenance of romantic relationships. The three components are the ventral vagal complex (VVC), sympathetic nervous system (SNS), and the dorsal vagal complex (DVC). The VVC, which is found only in mammals, fosters the development of complex social behaviours and has an inhibitory effect on sympathetic pathways to the heart. Therefore, the VVC promotes both self-soothing and prosocial behaviours (Porges, 1998). The VVC controls what is known as the social activation system which serves as the neurophysiological basis for the courting behaviours associated with seduction. By controlling facial expression, vocalization, and head tilt, the social engagement system is intimately involved in the communication of affect, signaling of availability, and promotion of proximity (Porges, 1998).

As the social engagement system functions to maintain a low and variable heart rate in safe environments, it can be indexed by HRV (Porges, 1998).

The SNS mobilizes and provides energy to defend a partner and to facilitate proximity for reproductive behaviours when separated (Porges, 1998). However, the SNS contributes to more than just the mobilization of fight-or-flight behaviours; it also promotes the physiological activation associated with sexual arousal. During the initial phases of sexual arousal, the SNS and VVC may function together to signal reproductive availability using facial expressions and vocalizations (Porges, 1998). This cooperation between the two systems is evident when facial and vocal expressions of sexual arousal appear in concert with facial flush, sweating and tachycardia.

The main function of the DVC is to produce immobilization in response to severe danger. In mammals, the activation of the DVC in response to threat is infrequent. However, the DVC has been linked to oxytocin and vasopressin which are associated with pair bonding. Porges (1998) proposed that the oxytocin released during coitus conditions the individual and increases the likelihood of subsequent sexual encounters. Further, oxytocin may modify the DVC's main function. Instead of producing immobilization due to fear, in the presence of oxytocin the DVC may produce an immobilization of passion, which encourages reproductive behaviours and enduring associations between the mate and the euphoric experiences accompanying mating behaviour. Over time, this modification leads to relatively permanent bonds between mates (Carter et al., 1997; Porges, 1998). Long-term romantic love may thus be a classically conditioned response with enduring resistance to extinction facilitated by the DVC.

Seduction requires many resources and states of immobilization are periods of vulnerability for mammals. Therefore, these processes occur only in safe environments with mutual trust as a defining feature. Trust and security may be facilitated by heightened HRV (Porges, 1998). In one study, HRV was negatively associated with general attachment anxiety and positively associated with perceptions of security in current attachment relationships (Diamond & Hicks, 2005). Men with high perceptions of security in current relationships showed more effective vagally mediated recovery from lab-induced anger (Diamond & Hicks, 2005). Interestingly, in the same study the physical presence of romantic partners did not prove to be associated with the degree of emotional reactivity or recovery. This finding indicates that participants internalized their model of attachment security, and did not simply rely on cues from their partners to regulate their emotions.

Successful mating and bonding require the coordination of all three systems. The VVC promotes seductive behaviour, and if courting is successful proximity between the prospective mating partners would be reduced. The SNS would then be activated and restrict mobilization to the physical activities associated with the preparation to copulate and copulation. Finally, in order to facilitate conception, post-coitus recovery, and the formation of pair bonds, the DVC would stimulate an immobilization system (Porges, 1998).

Based on Porges' (1995, 1998) theory, Schneiderman and colleagues (2011) set out to experimentally examine the association between HRV and adult romantic relationships. The results of their cross-sectional study indicated that, in comparison to single participants, individuals who had recently begun new romantic relationships demonstrated lower HRV reactivity. HRV reactivity was operationally defined as the difference in HRV in response to the negative and positive film stimuli. While these groups differed in their autonomic reactivity, recently coupled individuals rated the film stimuli to be equally distressing as did their uncoupled counterparts. This finding demonstrated that the stress buffering effects associated with higher HRV are not conscious. Schneiderman and colleagues' explained their results in the context of Porges' (1998) polyvagal theory on love.

Schneiderman and colleagues (2011) asserted that HRV became elevated during the process of courting associated with new romantic relationships. According to polyvagal theory HRV is a marker of the social engagement system (Porges, 1998). During seduction and the courting phase of a new relationship, the VVC and the social activation system dominate autonomic control and therefore lead to increased HRV. However, an alternative explanation of Schneiderman and colleagues' results may be that HRV is a cause, rather than a consequence, of romantic relationships.

Lower HRV reactivity may cause individuals to enter into romantic relationships. As noted earlier, higher HRV in response to stressors is associated with better health outcomes, well-being, physical attractiveness, and attachment security, which may all be indicative of higher mate value. Thus individuals with heightened HRV may be viewed as more attractive and have increased opportunity to form romantic relationships. In addition, according to polyvagal theory (Porges, 1995) the autonomic nervous systems of individuals with higher HRV are largely controlled by the VVC. Dominance of the VVC promotes activation of the social engagement system, thus leading to increased social competence. Studies of children diagnosed with autism have supported this association. In this population higher baseline HRV is associated with better social functioning (Patriquin, Scarpa, Friedman, & Porges, 2013). Research has also shown that higher HRV predicts increased frequency of penile-vaginal intercourse (Brody, 2000, 2003), better communication between romantic partners (Roisman, 2007), and lasting marriages (Gottman & Levenson, 1992). Thus it appears that individuals with heighted HRV have more opportunity and greater ability to begin and maintain romantic relationships. A prospective study is required to clarify the direction of the association between romantic relationships and HRV and to determine which explanation accounts for the observed differences in HRV reactivity between single and newly coupled individuals.

The Present Study

The purpose of the present study was to add to the understanding of the physiological and psychological processes associated with beginning a romantic relationship. A film exposure paradigm was used for the induction of neutral, positive, and negative emotions as previous research has shown that film clips elicit the same emotions in most individuals (Hagemann et al., 1999; Overbeek, van Boxtel, & Westerink, 2012; Philippot, 1993). These results have been confirmed through self-report, facial EMG, and HR responses (Overbeek et al., 2012). Film clips are also rated as eliciting stronger emotional experiences than still pictures (Overbeek et al., 2012). As Schneiderman and colleagues (2011) found that relationship-related film clips showed the largest differences in HRV for singles and newly coupled individuals, film clips made up of short relationship-related film segments were used to elicit the desired emotions.

This study utilized a longitudinal design to examine the association between HRV and romantic relationships. This methodological advancement allows for analysis of the sequential order of events to determine whether reduced HRV reactivity is a cause – or consequence – of being in a romantic relationship. Specifically, a cohort of single female university students were tested for HRV reactivity to film clips at baseline early in the first semester of the school year, and again after a follow-up period of up to 6 months in the latter part of the second semester. Change in relationship status from single to newly coupled was also monitored.

This study has two primary purposes. The first is to attempt a replication of key findings reported by Schneiderman and colleagues (2011). Specifically, this *replication* hypothesis asserts that at follow-up, compared to participants who remain single, their newly coupled counterparts will evidence (a) higher HRV in response to an emotionally evocative negative film clip and (b) milder change in vagal reactivity from positive to negative clips. Schneiderman and colleagues interpreted both findings as evidence for love causing a "buffered stress response" (p. 1318). However, given the cross-sectional nature of their methodology, assertions about cause cannot be claimed with certainty. Thus, two competing hypotheses may be posited to understand the relationship between HRV reactivity and relationship status:

1. The *consequence* hypothesis asserts that these newly coupled individuals will evidence a drop in HRV reactivity to film clips as their relationship status changes from single to coupled, while that for singles will remain unchanged.
2. The *cause* hypothesis states that single individuals with lower HRV reactivity at baseline will be more likely to enter into a new romantic relationship over the 6-month follow-up interval. Other variables that are associated with mate value such as attachment style, self-esteem, BMI, and emotional well-being will be examined for their potential moderating influence on this HRV-romance relationship.

Method

Participants

Ninety-one female participants were recruited through mass email (see Appendix A). A link to the initial online component of the study was provided in the email. The online material included participant information and consent forms (see Appendices B & C). To be eligible to participate individuals had to be (a) female, (b) not currently in a romantic relationship, and (c) interested in forming a monogamous heterosexual romantic relationship in the near future. Males were excluded due to documented sex differences in HRV (Acharya et al., 2004; Overbeek, van Boxtel, Westerink, 2012) and because of the nature of the film stimuli which depicted women as the protagonists. Participants had the opportunity to earn up to two bonus marks in their introductory psychology course at Lakehead University.

Of the 91 participants, eight were excluded from analyses; two due to technical errors (e.g., missed ECG recordings), two due to failure to comply with instructions, one because her relationship status changed between completing the online questionnaires and the baseline laboratory session, and three because of excessive ectopic beats. Of the remaining 83 participants, 47 (57%) returned and completed the follow-up laboratory session and thus comprise the sample of interest in the present study. Their mean age was 19.09 years (*SD* = 2.23). The majority identified their ethnicity as Caucasian (83 %), followed by East Asian (6.4%), South Asian (4.3%), African-Canadian (2.1%), and other (2.1%). Twenty-eight (60%) remained single while 19 (40%) became coupled over the 6-month follow-up, operationally defined as entering into a monogamous heterosexual romantic relationship lasting at least 10 consecutive days. The average duration into their new relationship was *M* = 37.2 days (*SD* = 18.23; range 10 - 66 days). The average score on the Passionate Love Scale was an item *M* = 5.36(*SD* = 0.37) indicative of a "moderately true" endorsement to the typical Passionate Love item. Four of 19 newly coupled participants endorsed "yes" to the item "are you currently in love?"(see part C question 4 in Appendix D).

Materials

Moderating variables. These variables were investigated as potential moderators of the association between HRV and relationship status. They were administered during the online questionnaire portion of the study.

1. Body Mass Index (BMI; Appendix D). On the Demographics Questionnaire (see below), participants reported their height (in.) and weight (lb.), from which their BMI was estimated using the formula BMI = weight (lb.) / (height [in.] x height [in.]) x 703.

2. Rosenberg Self-Esteem Scale (RSES; Appendix E). The RSES is a 10-item self-report measure that assesses global self-esteem (Rosenberg, 1965, 1979). Responses are given on a 4-point Likert-type scale, ranging from 1 (*strongly disagree*) to 4 (*strongly agree*). A sample item is "At times I think I am no good at all". A RSES total score was created by reverse scoring items 2, 5, 6, 8, and 9 and summing all items. Higher scores indicate higher self-esteem. The RSES has good internal consistency (α = .92; Rosenberg, 1979) and has demonstrated good test-retest reliability over a period of 2 weeks with correlations > .85 (Rosenberg, 1971). The RSES also correlates significantly with other measures of self-esteem, including the Coopersmith Self-Esteem Inventory (Robins, Hendin, & Trzesniewski, 2001). In addition, the RSES correlates in the predicted direction with measures of depression and anxiety (Rosenberg, 1979).

3. Attachment Style Questionnaire (ASQ; Appendix F). The ASQ is a 40-item self-report measure of how individuals currently view their attachment security with other adults (Feeney, Noller, & Hanrahan, 1994). Respondents rated how much they agree with each item on a 6-point scale ranging from 1 (*totally disagree*) to 6 (*totally agree*). Example items include "I prefer to depend on myself than other people," and "It's important to me that others like me". The original instrument is scored as five subscales; however, the current study used the alternative two-dimensional scoring method as described by Tasca et al. (2006) and Alexander, Feeney, Hohaus and Noller (2001). The two-dimensional model yields two insecure subscales: Anxious Attachment (AN), and Avoidant Attachment (AV). Tasca and colleagues reported the internal consistencies for the subscales as .76 and .85 for AV and AN subscales, respectively.

Alexander and colleagues reported coefficient alphas of .86 for both subscales. In the present study only the AN scale was used to operationally define attachment security. Higher scores indicate lower attachment security. The rationale for not including the AV scale is that for females anxious attachment, and not avoidant attachment, is related to choice of mating strategies. Further, the inclusion criteria of the present study required that single participants be motivated to form monogamous heterosexual romantic relationships. Thus, participants high on the AV scale would de facto screen out.

4. Kessler Psychological Distress Scale (K6; Appendix G). The K6 is a 6-item scale measuring general distress during the past 30 days (Kessler et al., 2002). An example item is "During the past 30 days, about how often did you feel this way... nervous?" Respondents rate items on a 5-point scale ranging from 0 (*None of the time*) to 4 (*All of the time*). The K6 questions originate from item response theory and have strong psychometric properties including $\alpha = .89$ (Kessler et al., 2002).

Variables addressing internal validity. These variables reflect upon aspects of the internal validity of the study.

1. Demographics Questionnaire (Appendix D). Part A was administered as part of the online questionnaires. It included questions to determine age, ethnicity, height, and weight. Part B was administered during the baseline laboratory session and invited participants to respond to three Likert-type scale questions assessing their motivation and expectancy to begin a romantic relationship before the end of the follow-up period. Part C specifically asked participants to declare their relationship status at the follow-up laboratory session. Newly coupled participants were further asked to declare the date at which their romantic relationship began and their love status.

2. Pleasantness Questionnaire (Appendix H). The Pleasantness Questionnaire was used as a manipulation check to ensure the film clips differed in their intended manner regarding affective valence (Rottenberg, Ray, & Gross, 2007). After watching each film clip participants rated the pleasantness of their feelings experienced while viewing the film clip on a 9-point Likert-type scale ranging from 0 (*unpleasant*) to 8 (*pleasant*).

3. Passionate Love Scale (PLS; Appendix I). The PLS is a 30-item self-report measure assessing the cognitive, emotional, and behavioural components of passionate love (Hatfield & Sprecher, 1986). The PLS was administered only to the 19 newly coupled participants at follow-up. Items were rated on a 9-point scale ranging from 1 (*Not at all true*) to 9 (*Definitely true*). Respondents were instructed to think of the person they currently most passionately love when answering the questions. Example items are "I have an endless appetite for affection from ___________," and "_________ always seems to be on my mind". The PLS is highly reliable and shows good internal consistency ($\alpha = .94$; Hatfield & Sprecher, 1986). The PLS shows strong convergent validity as it is significantly correlated with measures of relationship intimacy including a one-item indicant of passionate love ($r = .71$), Rubin's Love scale ($r = .85$; Rubin, 1970), Rubin's Liking scale ($r = .49$), self-reported commitment (r = .80), self-reported satisfaction with overall relationship ($r = .56$), and self-reported satisfaction with the sexual aspect of the relationship ($r = .44$; Hatfield & Spreacher, 1986).

Apparatus

Electrocardiogram. Electrocardiogram (ECG) was recorded using a 72-channel amplifier (Advanced Neuro Technology, Enschede, Netherlands), sampled at 1024 Hz. Participants were fitted with three electrodes with snap-on Ag-AgCI placed on cleaned skin located on the right clavicle and left abdomen below the rib in a lead II configuration. A ground electrode was applied to the left clavicle. Raw ECG data was extracted and inspected using ASA-Lab software (Version 16; Advanced Neuro Technology, Enshede, Netherlands) and then imported into Kubios HRV specialized analysis software (Biosignal Analysis and Medical Imaging Group; http://kubios.uef.fi/; version 2.1) to derive $HFms^2$ as the metric of HRV.

Procedure

Online survey. A mass e-mail (see Appendix A) was sent out to introductory psychology students, directing them to an online battery of psychometric questionnaires presented on Survey Monkey®, a web-based survey creator and distributor. Participants were informed that they could earn up to two bonus points toward their course final grade for participating in the study. One point was awarded after completion of the online survey and baseline laboratory session, and a second point after completion of the follow-up laboratory session. Participants began by reading and completing the participant information and consent forms (see Appendices B and C). Participants signified their voluntary consent to participate by clicking a box at the bottom of the screen. Participants then filled out the Demographics Questionnaire: Part A (Appendix D), followed by the RSES (Appendix E), the ASQ (Appendix f), the K6 (Appendix G). In total, the online session took approximately 30 min to complete. After completing these questionnaires, participants were given instructions to schedule their baseline laboratory session (Appendix J). Participants were asked to refrain from drinking alcohol for 24 hours, and eating, drinking caffeinated beverages, or exercising 2 hours before each laboratory session as these variables have been shown to affect HRV (Buchheit et al., 2004; Nederkoorn, Smulders, & Jansen, 2000; Sondermeijer, van Marle, Karmen, & Krum, 2002; Weise, Krell, & Brinkhoff, 1986).

Baseline laboratory session. A timeline of experimental procedures is outlined in Appendix K. During the baseline laboratory session, the experimenter greeted participants and offered instructions for attaching the ECG electrodes. Skin was cleaned with an alcohol solution prior to attaching the electrodes. Participants were then seated and asked to remain still while viewing 4:45-min film segments presented on a 72in. DLP television.

Film clips were compilations of thematically related shorter film clips (10 – 60 s) freely available from Gettyimages.com, an online digital media database. Selection of the clips was based on criteria recommended by Rottenberg and colleagues (2007). Ten pilot participants were asked to rate 100 of these short film clips and 12 classical music clips on the dimensions of emotional valence and arousal. The clips were presented on a 72 in. DLP television screen using PowerPoint 2010 and valence and arousal ratings were collected after each clip. Valence and arousal ratings were made using the Self-Assessment Manikin (Appendix L) on 1 (*unhappy, relaxed*) to 9 (*happy, stimulated*) scales. These ratings were used to construct two 4:45-min film clips for each valence (positive, neutral, negative) by amalgamating shorter clips and overlaying with music on iMovie '11 (version 9.0.4) video editing software. The final product was a pair of neutral, positive, and negative film clips rated by pilot participants as being equivalent to their counterpart in both valence and arousal. The two neutral clips had a mean valence score of 4.89 (SD = 1.12), with no film segments having means below 3.5 or above 6.5, and arousal scores of M = 2.22 (SD = 0.42). The positive film clips had average valence scores of 7.87 (SD = 1.01), with no individual film segments having means below 6, and arousal scores of M = 6.11 (SD = 1.27). Finally, the negative clips had average valence scores of 1.43 (SD = 0.60), with no film segments having means above 4, and arousal scores of M = 6.99 (SD = 1.07).

The final positive and negative film clips depicted heterosexual couples engaging in various activities chosen to elicit the target valence. Neutral clips depicted both individuals and couples engaging in emotionally neutral activities. The film clips were all geared towards women. Most clips depicted females as the main protagonists. Participants began by watching a 4:45-min neutral film clip that provided a baseline level of HRV. Subsequently, participants were randomly assigned to view either a 4:45-min positive or negative film clip. A second neutral film clip followed with the intent of limiting carryover effects. Research has shown that watching a neutral film clip is more effective at returning individuals to a cardiovascular baseline than a period of inactive rest (Overbeek et al., 2012; Piferi, Klein, Younger, & Lawler, 2000). Finally, participants viewed a 4:45-min film clip of the valence they have not yet watched (either positive or negative). After each clip, participants rated its valence on the pleasantness scale (Appendix H). Participants underwent the viewing of the positive and negative clips in counterbalanced order.

After viewing the clips the participants completed part B of the Demographics Questionnaire (Appendix D). Before departing the laboratory, participants read and completed a debriefing form for the baseline laboratory session (see Appendix M). A list of counselling resources was given to any participant who so requested (see Appendix N). The researcher also described the criteria that must be met before participants could return for follow up. Specifically, participants were asked to return to the laboratory either (a) when they have entered into a monogamous heterosexual romantic relationship that has lasted at least 10 consecutive days, or (b) at the end of the follow-up period, if they remained single. Participants who entered into a new romantic relationship were instructed to sign up for a follow-up session via Sona systems (http://www.sona-systems.com.), an online human subject pool management system.

Reminder emails (Appendix O) were sent to participants every 28 days regarding the above criteria for return to the laboratory.

Follow-up laboratory session. Baseline recordings were taken early in first semester and follow-up recordings were taken up to the latter part of second semester. This time frame was chosen to maximize the length of the follow-up period within the academic year. This follow-up session followed the same procedure as the baseline laboratory session with a few notable exceptions. First, participants were shown different film clips; however, these clips were designed to be equivalent in terms of both valence and arousal based on ratings from the pilot study. In order to counterbalance the presentation of the film compilations, the order of the positive and negative film clips was reversed from their presentation at baseline. Further, participants filled out part C of the Demographics Questionnaire instead of part B (Appendix D). Newly coupled participants were also asked to fill out the PLS (Appendix I). Finally, the session ended with a full debriefing (Appendix P).

Results

Analytic Strategy

The primary analytic techniques used for this study were moderated logistic regression, and mixed model analysis of variance (ANOVA). As in Schneiderman and colleagues' (2011) study, within-session HRV reactivity (Δ HFms^2) scores were computed by subtracting participants' HFms^2 while viewing the negative film clip from HFms^2 while viewing the positive film clip. Thus, positive Δ HFms^2 scores indicate a within-session reduction in HFms^2 from positive to negative clips.

The replication hypothesis was evaluated using two separate univariate ANOVAs comparing HFms^2 during the negative clip and Δ HFms^2 for singles and newly coupled participants at follow-up. To test the consequence hypothesis, a 2 (time) x 2 (relationship status) mixed model ANOVA was performed to evaluate within-participant change in Δ $HFms^2$ between baseline and follow-up with a specific, a priori interest in the newly coupled subgroup. The cause hypothesis was evaluated using moderated logistic regressions in the prediction of relationship status (Y) at follow-up (single vs. newly coupled) from Δ $HFms^2$ at baseline (X), with separate analysis for each of RSES, ASQ: AN, K6, and BMI as moderators (M).

Data for all analyses were assessed for violations of parametric assumptions to ensure accurate generalizations of the findings. All continuous variables were assessed for normality using z_{skewness}, calculated as skewness / *SE*. Any z_{skewness} scores of 1.96 and above were considered significantly skewed at $p < .05$ (Field, 2013). Significantly nonnormal variables were transformed using the natural log (ln). The assumption of homogeneity of variances for the ANOVAs was evaluated with Levene's test. The within-participant sphericity assumption of the ANOVA was verified using Mauchly's test and where violations occurred, the Greenhouse-Geisser corrected results were reported (Field, 2013).

For the logistic regression analyses, all predictor variables were mean centered to increase interpretability (Hayes, 2013). For these analyses the linearity of the logit was tested by assessing the significance of the interaction between the predictor and its log transformation (Hayes, 2013). Independence of errors was assessed by examining the dispersion parameters. All values were well below the cutoff of 2 indicating no problems with overdispersion (Hayes, 2013). Visual inspection of the scatterplots revealed no violations of the assumption of homoscedasticity or normal distribution (Aguinis, 2004). Further, the examination of the tolerance statistics for the regressions did not suggest any issues with multicollinearity. Finally, residuals were investigated to ensure that the model was a good fit for the data.

Data Preparation

Data was entered into SPSS v. 20. A technical error rendered one HRV recording unusable for one participant. That recording was replaced by a carry-forward of the neutral clip recording. Two data points for the PLS were missing accounting for less than 0.01% of ratings. Missing data points were replaced with prorated scores within individuals on the scales in question.

ECG recordings. Recordings were visually inspected for ectopic heart beats. Participants (n = 3) whose recordings breached the convention of five percent threshold for ectopic heart beats relative to total beats were excluded from analyses as per protocols outlined in the related QRSTool instruction manual (Allen, Chambers, & Towers, 2011). Using a fast Fourier transform (FFT) method, a distinct peak known as an R-spike was identified throughout the recording. Interval series between R-spikes were then calculated for each recording by power spectrum density (PSD), yielding HF as a discrete measures of high frequency HRV. HF was used as the metric of HRV in the current study and is expressed in absolute power (ms^2).

Psychometric variables. Descriptive information and indices of internal consistency pertaining to the psychometric variables are presented in Table 1. The K6 exceeded the cutoff for z_{Skewness} of 1.96 and was therefore subjected to the natural log transformation (ln), which produced a z_{Skewness} statistic = -0.40 and remedied the skew. The ln K6 was used in all further analyses. The z scores for all psychometric variables were analyzed for univariate outliers defined as ± 3.29 (Field, 2013); none were detected. An intercorrelation matrix for the psychometric variables can be found in Table 2. As expected, these variables are highly intercorrelated.

Table 1

Reliability Coefficients and Descriptive Statistics for Psychometric Variables

Variables	*M*	*SD*	Items	Actual Range	z_{Skewness}	α
RSES	30.04	4.96	10	8.00-29.00	-0.54	.88
ASQ: AN	41.66	11.77	13	13.00-61.00	-1.14	.90
K6	6.64	4.37	6	1.00-21.00	3.56	.82
PLS	160.77	11.09	30	76.00-254.00	0.24	.97

Note. $N = 47$ except for the PLS ($N = 19$) which was administered only to newly coupled individuals at follow-up. RSES = Rosenberg Self-Esteem Scale; ASQ: AN = Attachment Style Questionnaire Anxious subscale; K6 = Kessler Psychological Distress Scale; PLS = Passionate Love Scale; α = Cronbach's alpha internal consistency.

Table 2

Intercorrelations Among the Psychometric Variables

Variables	ASQ: AN	ln K6
RSES	-.74**	-.64**
ASQ: AN	–	.62**
ln K6		–

Note. $N = 47$. RSES = Rosenberg Self-Esteem Scale; ASQ: AN = Attachment Style Questionnaire, Anxious Subscale; ln K6 = log transformed Kessler Psychological Distress Scale.

Body Mass Index. BMI ($M = 22.31$, $SD = 2.84$, range = 17.47 – 31.01) was found to be significantly skewed in the positive direction, $z_{\text{Skewness}} = 2.01$. A logarithmic transformation corrected the skew to within acceptable levels, $z_{Skewness} = 0.84$, and examination of *z* scores revealed no outliers. The ln BMI variable was used in all analyses.

Comparison of Completers and Noncompleters

Separate univariate ANOVAs were conducted on each demographic and psychometric variable to determine whether study completers differed from those that did not complete the follow-up laboratory session. Results are presented in Table 3. The only variable to reach statistical significance was BMI; completers were lower than noncompleters.

Table 3

Comparison of Variables by Follow-up Completion Status

	Completers (n = 47)		Noncompleters (n = 36)				
Variables	*M*	*SD*	*M*	*SD*	F^b	*p*	$\eta^2_{partial}$
Age	19.09	2.23	19.03	2.36	0.01	.91	< .01
Motivation 1[a]	1.85	0.76	2.09	0.97	1.56	.22	.02
Motivation 2[a]	1.85	0.13	2.09	0.15	2.68	.11	.03
Expectancy[a]	2.60	1.94	3.17	1.78	1.89	.17	.02
ln BMI	3.10	0.13	3.18	0.20	4.79	.03*	.06
RSES	30.04	4.69	29.25	4.94	0.52	.47	< .01
ASQ: AN	41.66	11.77	42.78	9.37	0.22	.64	< .01
ln K6	1.88	0.57	1.85	0.56	0.06	.82	< .01

Note. RSES = Rosenberg Self-Esteem Scale; ASQ: AN = Attachment Style Questionnaire Anxious subscale; ln K6 = log transformed Kessler Psychological Distress Scale.
[a]Item can be found in the Demographics Questionnaire (Appendix A)
[b]*df* = 1, 81 except motivation 1, *df* = 1, 78.
*p < .05

Comparison of Single and Newly Coupled Participants

The same variables were analyzed for potential group differences as a function of relationship status. Newly coupled participants had significantly lower BMI and a trend towards greater motivation to begin a romantic relationship (see Table 4).

Affective Responses to Film Clips

Descriptive statistics pertaining to the pleasantness ratings of film clips can be found in Table 5. Significant negative skew in the data distributions was observed for the first neutral clip at baseline and positive skew in the negative clip at follow-up. A variety of transformations were applied to pleasantness ratings, each resulting in significant skewness for other film clips. Therefore, the untransformed pleasantness ratings were used all analyses. Two outliers, defined as *z* scores equivalent to or exceeding ± 3.29, were identified for the pleasantness ratings of the positive film at baseline. These outliers were replaced with the next highest nonoutlier value (Field, 2013).

A 4 (valence) x 2 (time) x 2 (relationship status) mixed model ANOVA was conducted to determine whether pleasantness ratings varied as a function of clip valence (neutral 1, positive, neutral 2, and negative), the time at which pleasantness of the clips was assessed (baseline vs. follow-up), or whether participants were single or newly coupled at follow-up. Mauchly's test was significant for valence, $\chi^2(5) = 14.07$, $p < .05$, $\varepsilon = .83$; thus Greenhouse-Geisser corrected scores were reported for effects related to that variable. A main effect was found for valence of the film clip, $F(2.49, 11.64) = 217.71$, $p < .001$, $\eta^2_{partial} = .83$ (see Figure 1). Simple non-orthogonal contrasts were calculated wherein each category is compared to the first category (neutral 1). These contrasts revealed that pleasantness ratings were significantly higher for the positive clip than the first neutral clip, $F(1, 44) = 104.04$, $p < .001$, $\eta^2_{partial} = .70$, whereas the

Table 4

Comparison of Variables by Relationship Status

	Singles (n = 28)		Newly Coupled (n = 19)				
Variables	*M*	*SD*	*M*	*SD*	F^a	*p*	$\eta^2_{partial}$
Age	19.18	2.72	18.95	1.22	0.12	.73	< .01
Motivation 1	1.67	0.56	2.11	0.94	3.97	.05*	.08
Motivation 2	3.00	1.59	3.74	1.79	2.20	.15	.05
Expectancy	2.25	1.71	3.11	2.18	2.26	.14	.05
ln BMI	3.13	0.13	3.05	0.11	5.10	.03**	.10
RSES	30.75	4.54	29.00	5.47	1.42	.24	.03
ASQ: AN	41.29	10.80	42.21	13.36	0.07	.80	< .01
ln K6	1.82	0.59	1.97	0.54	0.79	.38	.02

Note. RSES = Rosenberg Self-Esteem Scale; ASQ: AN = Attachment Style Questionnaire Anxious subscale; ln K6 = log transformed Kessler Psychological Distress Scale.
[a]*df* = 1, 45, except Motivation 1, *df* = 1, 43
**p* < .06, ** *p* < .05

Table 5

Descriptive Statistics of the Pleasantness Ratings of Film Clips

	Neutral 1			Positive			Neutral 2			Negative		
	M	*SD*	z_{Skew}	*M*	*SD*	z_{Skew}	*M*	*SD*	z_{Skew}	*M*	*SD*	z_{Skew}
Baseline	4.38	1.55	-2.17	6.17	1.43	-1.83	3.72	1.66	-0.89	0.56	0.47	1.82
Follow-up	4.36	1.59	0.23	6.62	1.23	-1.99	4.15	1.69	0.35	0.87	1.07	4.05

Note. $N = 47$. $z_{\text{skew}} = z_{\text{skewness}}$.

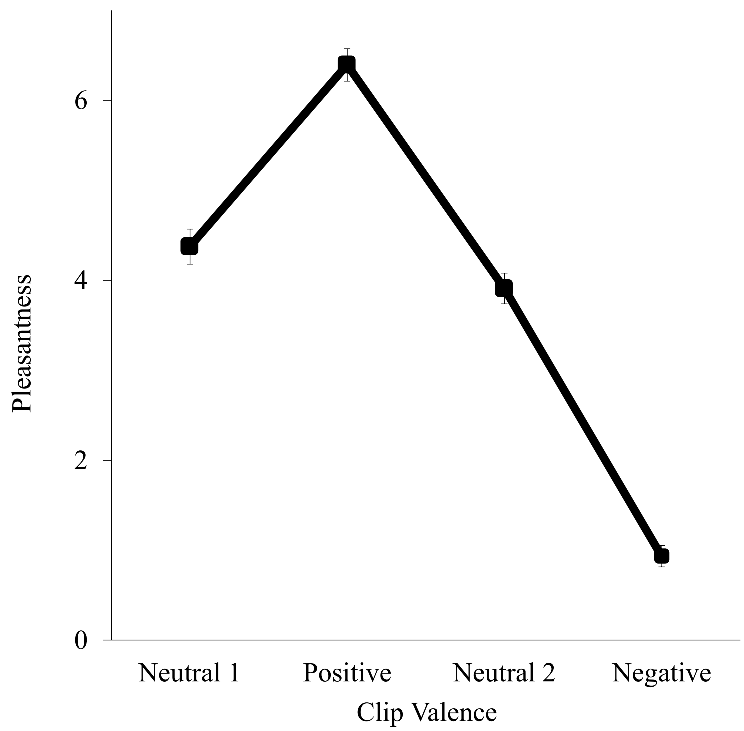

Figure 1. Mean (± 1 *SE*) pleasantness ratings plotted as a function of clip valence.

latter was significantly higher than the second neutral clip $F(1, 44) = 8.76$, $p < .01$, $\eta^2_{partial} = .17$, and the negative clip, $F(1, 44) = 185.78$, $p < .001$, $\eta^2_{partial} = .81$.

The remaining main effects were nonsignificant for time, $F(1,44) = 0.95$, $p = .34$, $\eta^2_{partial} = .02$, and relationship status, $F(1, 44) = 0.07$, $p = .93$, $\eta^2_{partial} < .001$. Further, the three two-way and one three-way interaction terms were also nonsignificant (*p*s > .05). Thus film clips evoked emotions of the appropriate valence which were not affected by time of presentation or the relationship status of the participant.

HRV Responses to Film Clips

At baseline and follow-up $HFms^2$ was significantly skewed in the positive direction across all four clip valences with $z_{skewness}$ statistics exceeding the convention of 1.96 (see Table 6). These data distributions were subjected to the ln transformation which resolved the skew,

Table 6

Descriptive Statistics of the HRV Recordings During Clips

	Neutral 1			Positive			Neutral 2			Negative		
	M	*SD*	z_{Skew}	*M*	*SD*	z_{Skew}	*M*	*SD*	z_{Skew}	*M*	*SD*	z_{Skew}
Baseline												
HFms^2	685.34	691.38	4.73	553.60	621.69	6.77	538.89	520.70	5.90	612.70	652.24	6.67
ln HFms^2	6.01	1.12	-1.28	5.86	0.95	0.73	5.93	0.85	0.55	5.94	1.04	-0.98
Follow-up												
HFms^2	859.07	1150.19	8.67	815.85	1184.35	10.38	838.96	10.91	2.84	850.42	986.88	7.35
ln HFms^2	6.13	1.15	0.32	6.09	1.12	0.00	6.12	1.15	0.36	6.20	1.11	-1.01

Note. $N = 47$. $z_{\text{skew}} = z_{\text{skewness}}$, ln HF = log transformed HFms^2.

producing $z_{skewness} < 1.96$ at all four clips. Consequently, ln $HFms^2$ was used in the remainder of the analyses. Upon inspection of *z* scores, no outliers were identified for ln $HFms^2$.

As with pleasantness ratings, a 4 (valence) x 2 (time) x 2 (relationship status) mixed model ANOVA was conducted to determine whether ln $HFms^2$ varied as a function of clip valence (neutral 1, positive, neutral 2, and negative), the time at which ln $HFms^2$ was assessed (baseline vs. follow-up), or relationship status (single vs. newly coupled). Mauchly's test was significant for valence, $\chi^2(5) = 13.38$, $p < .05$, $\varepsilon = .82$; thus Greenhouse-Geisser corrected scores were reported for the effects pertaining to that variable. All main effect terms were nonsignificant; valence, $F(2.47, 111.01) = 1.38$, $p = .25$, $\eta^2_{partial} = .03$, time, $F(1,45) = 1.64$, $p = .21$, $\eta^2_{partial} = .04$, and relationship status, $F(1,45) = 0.14$, $p = .71$, $\eta^2_{partial} < .01$ did not significantly affect ln $HFms^2$. Further, the three two-way and one three-way interaction terms were nonsignificant (*p*s > .05). Thus, unlike pleasantness ratings, the valence of neither baseline nor follow-up clips systematically affected ln $HFms^2$ in the completer subgroup.

To explore the potential effect of clip valence at baseline upon HRV within the larger group of participants ($N = 83$), a 4 (valence) x 2 (completer status: completer vs. noncompleter) mixed model ANOVA was conducted. Mauchly's test was significant, $\chi^2(5) = 26.92$, $p < .001$, $\varepsilon = .83$. Results revealed a trend towards significance for clip valence, $F(2.48, 200.49) = 2.74$, $p = .055$, $\eta^2_{partial} = .03$ (see Figure 2). No significant effects were found for completer status, $F(1, 81) = 0.44$, $p = .51$, $\eta^2_{partial} = .01$, or the Valence x Completer Status interaction, $F(2.48, 200.49) = 0.37$, $p = .74$, $\eta^2_{partial} = .01$.

To further explore the trending main effect for clip valence, a series of simple contrasts were calculated. $HFms^2$ during positive clip was significantly reduced from the first neutral clip, $F(1, 81) = 4.99$, $p < .05$, $\eta^2_{partial} = .06$. The remaining contrasts against the first neutral clip were

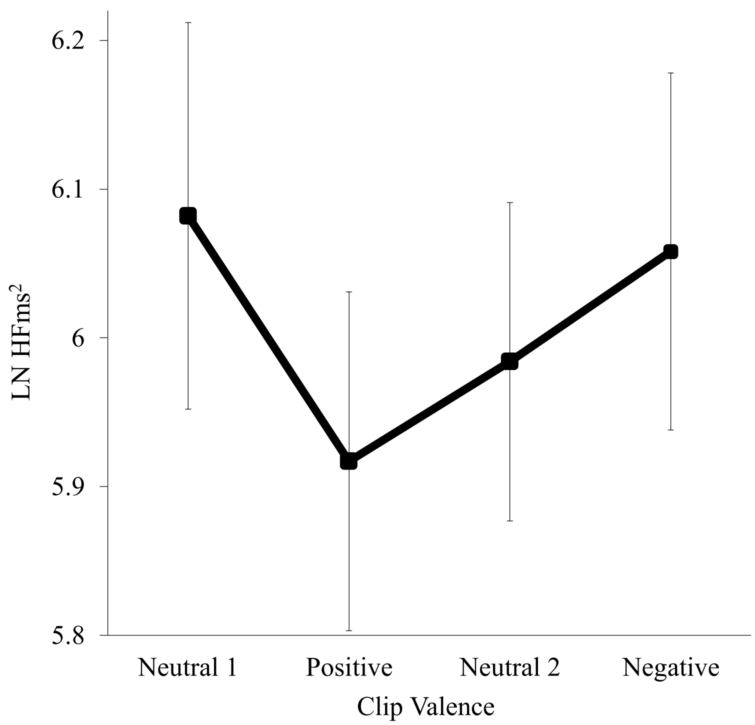

Figure 2. Mean (± 1 *SE*) ln $HFms^2$ plotted as a function of clip valence.

nonsignificant; $HFms^2$ during the first neutral clip was not significantly different from either $HFms^2$ during the second neutral clip, $F(1, 81) = 2.33$, $p = .13$, $\eta^2_{partial} = .03$, or the negative clip, $F(1, 81) = 0.178$, $p = .67$, $\eta^2_{partial} < .01$. Thus, completers were no different than noncompleters in terms of their HRV responses to clips. However, within the larger sample there was a trend towards a significant main effect of clip valence, driven by a reduction in $HFms^2$ from the first neutral to the positive clip.

Recall that Δ ln $HFms^2$ was created by subtracting the ln $HFms^2$ during the negative clip from the ln $HFms^2$ during the positive clip. A positive difference score indicates a reduction in ln $HFms^2$ from the positive to negative clips. Descriptive statistics for these change scores are presented in Table 7. The *z* scores were analyzed and one outlier was found for ln $\Delta HFms^2$ at follow-up. It was replaced with the next lowest nonoutlier.

Table 7

Descriptive Statistics of Δ ln HFms²

	Baseline			Follow-up		
	M	*SD*	$z_{skewness}$	*M*	*SD*	$z_{skewness}$
Δ ln HFms²	-0.08	0.61	-0.31	-0.06	0.43	1.17

Note. *N* = 47. Δ ln HFms² = log transformed HF reactivity score

Replication Hypothesis

Contrary to expectations, newly coupled participants did not differ from their single counterparts at follow-up with regard to (a) ln HFms² during the negative clip; *M*s = 6.21 (*SD* = 1.00) and 6.12 (*SD* = 1.25), for singles and newly coupled participants respectively, $F(1,45) = 0.09$, $p = .77$, $\eta < .01$, or (b) Δ ln HFms²; *M*s = -0.12 (*SD* = 0.37) and 0.02 (*SD* = 0.50), for single and newly coupled participants respectively, $F(1,45) = 1.14$, $p = .29$, $\eta = .03$. These results do not provide evidence of a buffered stress response amongst the newly coupled participants.

The Consequence Hypothesis

It was predicted that newly coupled participants at follow-up would show reduced Δ ln HFms² when compared to their baseline values, whereas Δ ln HFms² for singles would remain unchanged over time. A 2 (time) x 2 (relationship status) mixed model ANOVA was conducted to determine if Δ ln HFms² varied as a function of time (baseline vs. follow-up) or relationship status (single vs. newly coupled). No significant effects were observed for time, $F(1,45) = 0.14$, $p = .71$, $\eta < .01$, relationship status, $F(1,45) = 0.01$, $p = .91$, $\eta < .01$, or their interaction, $F(1,45) = 1.03$, p = .32, $\eta = .02$.

As newly coupled participants were of particular interest, a repeated measures ANOVA was conducted on this sample (*n* = 19) to investigate the a priori prediction that Δ ln HFms² would decrease from baseline to follow-up. Results revealed no significant main effect of time, $F(1,18) = 0.55$, $p = .47$, $\eta = .03$. Thus, results do not support the consequence hypothesis that HRV reactivity decreases as a function of beginning a new romantic relationship.

The Cause Hypothesis

The alternative hypothesis predicted that individuals with higher Δ ln $HFms^2$ at baseline would be less likely to form new relationships over the course of the follow-up period. Recall that positive Δ ln $HFms^2$ scores indicate a within-session reduction in ln $HFms^2$ from positive to negative film clips. To examine this prediction, four moderated logistic regressions were performed. Baseline Δ ln $HFms^2$ was used to predict relationship status at follow-up, with a separate analysis for each of RSES, ln K6, ASQ: AN, and BMI as moderators. Relationship status was coded 0 = single and 1 = newly coupled.

The unstandardized regression coefficients for each of the four analyses are presented in Table 8. The overall models with ln K6 and RSES as moderators were not significant (ps $< .05$), indicating that the addition of these predictor variables did not significantly improve the fit of the data from the constant-only model (Field, 2013). The overall model for moderator ASQ: AN was also not significant and therefore no better than the constant-only model in predicting relationship status at follow-up (Hayes, 2013). However, this model produced a significant Δ ln $HFms^2$ x ASQ: AN interaction. When using a simultaneous regression model, as in the present study, it is suggested that a significant overall R^2 be required before examining individual effects (Bedeian & Mossholder, 1994). In light of this recommendation, the Δ ln $HFms^2$ x ASQ: AN interaction was not interpreted.

The final regression with the moderator BMI revealed that the predictors as a set reliably distinguished between single and newly coupled participants at follow-up. Upon examining the

Table 8

Unstandardized Moderated Regression Coefficients Predicting Relationship Status at Follow-up

	Moderator			
Variable	RSES	ln K6	ASQ: AN	BMI
ΔLN $HFms^2$	-0.33 (0.52)	-0.43 (0.52)	-0.55 (0.58)	0.30 (0.71)
Moderator	-0.08 (0.06)	0.32 (0.60)	0.01 (0.03)	-9.10 (3.76)*
Δ ln $HFms^2$ x Moderator	-0.09 (0.11)	1.39 (1.26)	0.15 (0.07)*	14.57 (6.84)*
Constant	-0.41 (0.31)	-0.41 (0.31)	-0.45 (0.32)	-0.70 (0.36)
Overall model				
Cox & Snell R^2	.05	.05	.12	.23
$\chi^2(3)$	2.48	2.48	6.07	12.24**

Note. $N = 47$. RSES = Rosenberg Self-Esteem Scale, ln K6 = log transformed Kessler Psychological Distress Scale, ASQ: AN = Attachment Security Questionnaire: Anxious subscale.
* $p < .05$, ** $p < .01$

residuals, one multivariate outlier was identified. When this individual was removed from the analysis there were no appreciable changes to the model prediction; therefore, that outlier was retained in the final analysis. The Hosmer and Lemeshow test was nonsignificant, $\chi(7) = 5.28$, $p = 0.63$, indicating good model fit. Prediction success overall was 72.3% (92.9% for singles and 42.1% for newly coupled). The conditional (simple) effect of ln BMI on relationship status was significant, as well as the Δ ln $HFms^2$ x ln BMI interaction. Evident in Figure 3 is the

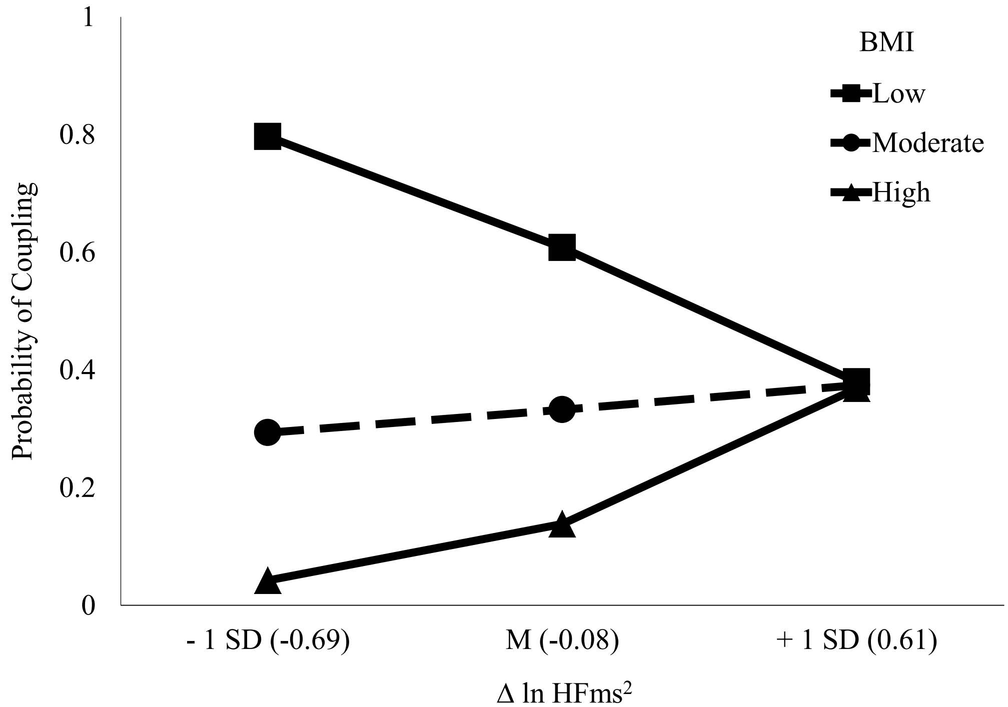

Figure 3. Probability of coupling over the follow-up period plotted as a function of Δ ln HFms^2 moderated by BMI.

observation that low Δ ln HFms^2 enhances probability of coupling when participants are low–but not high–in BMI. Negative Δ ln HFms^2 scores indicate that participants exhibited a higher ln HFms^2 response to the negative clip. Therefore, heightened ln HFms^2 during the negative relative to the positive film clip is beneficial to women with low BMI, whereas the reverse is true for high BMI women. Among participants with higher ln HFms^2 during the positive relative to the negative clip (i.e., high Δ ln HFms^2), the probability of coupling was at the overall coupling rate of approximately 40%, regardless of BMI.

Discussion

The purpose of the present study was to elucidate the relationship between HRV and romantic relationships. A film exposure paradigm was used to evoke changes in HRV. As expected, film clips induced emotions of the appropriate valence as evidenced by the pleasantness ratings. When examining the larger sample of all participants who completed baseline HRV measurements, a trend towards film clips systematically affecting HRV was also observed; however, the direction of this relationship was unexpected. The trend revealed a reduction in HRV from the first neutral clip to the positive clip, but not the neutral to the negative clip. Typically, studies investigating HRV reactivity report that psychological stressors of all intensities cause vagal withdrawal and a corresponding decrease in HRV from baseline levels (Friedman, 2007; Thayer & Lane, 2000). The finding in the current study that HRV did not decrease in response to the negative clip could be explained by attributes of the specific stimuli.

Exposure to emotion-inducing pictures and film clips has been widely used to investigate cardiac responding (Palomba, Sarlo, Angrilli, Mini, & Stegagno, 2000). Pictures and clips are typically preferred over other methods of inducing stress (e.g. the public speaking paradigm) as the passive exposure to visual stimuli is thought to enhance the effects of affective processing and produce more consistent results (Palomba et al., 2000). Emotion research has shown that viewing affective scenes of any valence can cause sustained cardiac deceleration, particularly during the viewing of unpleasant scenes (Bradley, Greenwald, & Hamm, 1993; Lang, Greenwald, Bradley, & Hamm, 1993; Palomba et al., 1997). Unpleasant stimuli evoking sadness and disgust (particularly depicting mutilations, injuries, or blood), as opposed to other negative emotions such as anger or fear, provoke larger heart rate decreases (Bradley et al., 1993; Gross and Levenson, 1993; Palomba & Stegagno, 1993). Cardiac deceleration is associated with increased HRV. In the present study heart rate was inversely related to HRV during the first neutral film (r = - .60). In contrast to the HRV literature, emotion research supports the notion that unpleasant emotions may not always evoke a sympathetic response; parasympathetic, or mixed reactions may occur depending on the particular subject matter.

Palomba and colleagues' (2000) results indicate differential autonomic response patterns are produced as a function of the specific content of unpleasant films. They exposed participants to a neutral landscape film clip, a film clip depicting threatened assault with a knife, and a surgical film clip. These researchers did not find significant differences in HRV levels for the different films; however, other autonomic indicators differed. The threat film produced a typical defense response characterized by cardiac acceleration, decreased T-wave amplitude, and increased skin conductance. These results are consistent with previous findings of relative cardiac activation during threat compared with other unpleasant material (Levenson, 1992; Bradley et al., 1993; Palomba & Stegagno, 1993). The surgery film, on the other hand, produced a mixed autonomic activation marked by decreased b-adrenergic and increased cholinergic sympathetic activity. Heart rate reductions during the second part of the surgery film were paralleled by decreased skin conductance and increased T-wave amplitude, indicating sympathetic withdrawal or even increased parasympathetic cardiac control (Palomba et al., 2000). These results suggest that distinct autonomic patterns are a function of the specific nature of negative events. Clearly, threatening stimuli are able to evoke the classic sympathetic fight-or-flight reaction that accompanies fear, whereas blood, injuries and mutilations evoke sad or disgusted emotions and a mixed or primarily parasympathetic cardiac response.

In the current study, the negative stimuli was made up of smaller film clips depicting a variety of negative events including the sickness of a romantic partner, a child crying while parents fight, and a battered woman. An interpretation of the current results based on Palomba and colleagues' (2000) findings is that across relationship statuses, participants were not threatened by the negative film clips, but instead disgusted and saddened. This sad and disgusted affect therefore accounts for the equivalence in HRV between the neutral and negative clips, rather than the predicted decrease from neutral to negative clips.

At a theoretical level, Porges' (2003) polyvagal theory may shed some light on why sad and disgusting stimuli produce different cardiac responses to threatening stimuli. As previously noted Porges described the two most influential components of mammals' autonomic nervous systems. The first of these, the myelinated vagus, is linked to social communication, self-soothing, and calming through parasympathetic dominance. HRV is often used as the index of this so-called social engagement system. The second and rival system, the sympathetic-adrenal network, is responsible for active avoidance or sexual activity, depending on the context. Based on this theory, the threatening film clips will activate the sympathetic system and the ensuing fight-or-flight response. Saddening or disgusting film clips may instead activate the myelinated vagus to promote self-soothing and increase parasympathetic activation.

Another possible explanation for HRV not decreasing during the negative film clip is that it has been shown to increase in response to successful emotion regulation (Ingjaldsson et al., 2003; Smith et al., 2011), thereby facilitating further effective emotional management. Ingjaldsson and colleagues (2003) demonstrated an increase in HRV in recovering alcoholics who easily resisted a drink in response to alcohol cues. By contrast, recovering alcoholics that reported an urge to drink did not exhibit increased HRV during the alcohol cues. Lane and colleagues (2009) have further shown that increases in HRV are accompanied by parallel cerebral blood flow changes in areas identified as being important in emotional regulation and inhibitory processes. Indeed, there is substantial evidence that HRV is linked to the processes of emotional perception, responding, and regulation (Beauchaine, 2001). Successful regulation of emotions during the negative film clip may account for the observation in the present study that HRV failed to decrease in response to the negative film clip.

While film clips may be the preferred affective stimuli in current studies, historically still pictures have most often been used due to difficulty constructing balanced film stimuli. Research has shown differences between cardiac responses to still pictures and film clips, most likely because film clips require the synthesis of a greater amount of emotionally-relevant information (Davis, Hull, Young, & Warren, 1987; Lazarus, 1972). Long lasting visual stimuli, such as films, have been shown to produce a diphasic cardiac reaction by which an abrupt shift occurs from a sympathetically mediated pattern to an opposing increase in parasympathetic activity (Öst, Sterner, & Lindahl, 1984). However, this diphasic pattern was not evident when slides or still images were used as stimuli (Hamm, Cuthbert, Globisch, & Vaitl, 1997; Klorman, Weissberg, & Wiesenfeld, 1977). The differing attentional requirements of the mediums may potentially explain the discrepant findings between the present study and a larger body of research, which has mainly relied on still images.

Taken together, these results suggest that cardiac response is highly specific to the emotional content and medium of negative stimuli. The film clips in the current study may have been perceived by all participants across relationship statuses as saddening and disgusting, rather than threatening, and thus did not evoke the expected sympathetic activation. Alternatively, successful emotion regulation during the negative clips may account for this finding.

Despite these unanticipated results, the exploration of the hypotheses was not hindered. The goals of the present study were twofold. First, this study attempted to replicate Schneiderman and colleagues' (2011) findings that newly coupled individuals experienced overall higher levels of HRV and lower HRV reactivity. Secondly, this association between HRV and romantic relationships was further clarified by examining two competing hypotheses.

Replication Hypothesis

Unlike Schneiderman and colleagues' (2011) findings, no statistically significant differences in HRV were observed during the negative clip or overall HRV reactivity between the singles and newly coupled individuals at follow-up. Schneiderman and colleagues reported that the typical vagal withdrawal and stress response was absent in newly coupled individuals when exposed to relationship-related stressors. In their sample, newly coupled participants experienced higher HRV during the negative relationship-related film as compared to the positive relationship-related clip; this pattern was reversed for single participants, who showed a more typical vagal withdrawal and a decrease in HRV when presented with the negative relationship-related stimuli. Explanation for the failure to replicate Schneiderman and colleagues' findings in the present study can be drawn from one of two sources. First, few studies report this buffered stress response for the newly coupled. This finding may not have been robust. However, the discrepancies may also be the product of the specific content of the negative stimuli.

The negative relationship-related film clip in Schneiderman and colleagues' (2011) study depicts a couple quarreling over an infidelity. It is conceivable that single and newly coupled individuals may have different emotional responses to this clip, although no differences appeared in their self-reported emotions. Newly coupled participants may have felt less threatened and more disgusted by the negative relationship-related film clip than their single counterparts, accounting for the increased parasympathetic activity noted for the new lovers. As discussed previously, the disgusting and saddening content of the negative clips in the present study did not produce sympathetic activation. Thus, differences between the negative stimuli in Schneiderman and colleagues' and the present study may account for the differential HRV response patterns. This explanation would indicate that the stress buffering effects of love and romantic relationships are specific to threatening stimuli. Further study is required to determine the cause of the inconsistent results. As they stand, the cross-sectional results of the current study at follow-up indicate that singles and newly coupled individuals do not differ in terms of their HRV responses to clips.

The Consequence Hypothesis

To test the consequence hypothesis, HRV reactivity at baseline and follow-up was compared for both single and newly coupled participants; no significant effects were found. Specific investigation of the newly coupled subsample over time revealed no changes in HRV as relationship status changed from single to newly coupled. Consequently, contrary to Schneiderman and colleagues' (2011) contention, beginning a new romantic relationship does not appear to 'buffer' vagal withdrawal in response to stressors. With this hypothesis unsupported by the data, the alternative explanation for Schniederman and colleagues' (2011) finding of a link between HRV and romantic relationships was explored.

The Cause Hypothesis

The cause hypothesis predicted that, instead of relationships causing reduced HRV reactivity, individuals with initially lower HRV reactivity would be more likely to become coupled over the course of the study. In a safe, plentiful, and mate rich environment, such as a North American university campus, intermediate- and long-term mating strategies are the most adaptive for women. Therefore, for these women a monogamous romantic relationship is the most effective mating strategy. HRV reactivity did predict later success in using long-term mating strategies, but only when the moderating influence of BMI was taken into account. As one might expect, women with lower BMIs were more likely to become coupled, but unexpectedly only if they experienced lower HRV reactivity (i.e., less of a decrease in HRV from the positive to negative film clips). In fact, 80% of thinner women with lower HRV reactivity became coupled over the course of the study compared to only 39% of thinner women with higher HRV reactivity. Women with higher BMIs, on the other hand, showed the opposite response pattern; lower HRV reactivity was associated with a lower likelihood of becoming coupled with only 4% of higher BMI women becoming coupled over the course of the study compared to 38% of higher BMI women with higher HRV reactivity.

It is important to keep in mind the calculation of HRV reactivity when interpreting these results. Unlike traditional HRV reactivity scores which subtract HRV in response to a stressor from baseline HRV, the current method of reactivity calculation takes into account HRV reactions to both the positive and negative stimuli. In Schneiderman and colleagues' (2011) and the present study, reactivity scores were created by taking the difference between the HRV during the positive and negative clips. Higher positive reactivity scores thus indicate higher HRV in response to the positive clip than the negative clip. Lower negative scores indicate the opposite, higher HRV during the negative versus the positive clip. Having higher HRV in response to the negative film clip may be adaptive as HRV is linked to better emotion regulation. With this information in mind, the current finding can be restated as women with lower BMI who have higher HRV in response to negative versus positive clips were the most likely to become coupled.

Research has shown a strong relationship between BMI and ratings of physical attractiveness. Tovee and Cornelisson (2001) found BMI of 19 to be the most attractive for women. The average BMI in the present sample was 22, with only six participants with BMIs below 19. Based on evolutionary theory, BMI serves as a basis for mate selection because it provides a reliable cue to female health (Manson et al., 1995; Willet et al., 1995) and reproductive potential (George, Swami, Cornelissen, & Tovée, 2008; Lake, Power, & Cole, 1997). Women's physical attractiveness, particularly bodily attractiveness, influences their mating strategy (Perilloux, Cloud, & Buss, 2012). Low BMI men and women are chosen more often by their speed dating partners, indicating that thin individuals are given more opportunities to begin romantic relationships (Asendorpf, Penke, & Back, 2011). However, although low BMI individuals are more attractive to the opposite sex, they are also more particular in choosing a mate.

A mating strategy often employed by high BMI women is to couple with other high BMI partners. Research has shown that obese individuals engage in assortative mating with other overweight individuals (Speakman, Djafarian, Stewart, & Jackson, 2007). Assortative mating, as defined by Speakman and colleagues (2007), is the "tendency toward nonrandom mating of individuals with respect to phenotype and cultural factors" (p. 316). A woman's BMI reflects her mate value. Thus, as a woman's BMI increases and levels of attractiveness decrease, she consciously compensates by targeting potential partners with the appropriate physical attractiveness level (George et al., 2008). Because mating competition can be costly, it is often to an individual's advantage to assess the relative mate value of potential rivals before competing with them. As high BMI women have little chance of outcompeting low BMI women, time and energy would be saved by forgoing or avoiding competition with those rivals. Thus, an effective mating strategy for less attractive women would be to target not what they regard as the potential partner with the highest mate value, but rather the most attractive individuals that they would be likely to successfully court (George et al., 2008). This arrangement is particularly well suited for females as physical attractiveness is deemed less important in a partner by females and many women are willing to trade good looks for future investment in offspring (Sugiyama, 2005).

Together these results indicate that mating strategies vary with BMI. Higher BMI women are less particular or choose less attractive mates to compensate for their own lower levels of mate value. In the current study, however, the results indicate a more complex relationship between BMI and relationship status. The interaction between HRV reactivity and BMI predicted who became coupled at follow-up. Lower HRV reactivity, defined in the current study as having higher HRV during the negative versus positive clips, is typically associated with better social functioning; however, in the present study it appeared to hinder the chances of higher BMI women finding a romantic partner. Research has shown that higher resting HRV and lower HRV reactivity are associated with higher mate value including better mental and physical health, emotion regulation, self-esteem, and social prowess. Higher BMI women with otherwise higher mate value (as evidenced by low HRV reactivity) would be choosier in regards to mate selection, a strategy typically only successful for low BMI women. This may explain why low HRV reactivity women with higher BMI had lower coupling rates. Interestingly, within the high HRV reactivity group, coupling rates remain near 40% regardless of BMI. Thus, higher HRV reactivity tends to overpower other traits when predicting who becomes coupled.

Limitations and Future Directions

While the longitudinal design of the present study provides a strong methodological advancement over previous research, the study was not without limitations. Most apparent was the high dropout rate between the first and second laboratory sessions. Less than 60% of eligible participants returned for follow-up, reducing the power of all analyses including variables measured at follow-up. However, the completers were comparable to noncompleters on most demographic and psychometric variables. The only exception was BMI with completers tending to have lower BMI than noncompleters. Further, many systematic interindividual variables have been shown to impact HRV. Exercise, caffeine, alcohol, and food consumption were controlled for in the study. However, other variables such as time of day and the menstrual cycle may also have had substantial impacts on HRV (Bassiouny et al., 2002; Leicht, Hirning, & Allen, 2003; Sato, Miyake, Akatsu, & Kumashiro, 1995).

The study also suffers from several limitations regarding measurement validity. BMI was based on self-reported height and weight rather than laboratory measurements. Self-reported weight is often underreported and biased by body image dissatisfaction (Gil & Mora, 2011; McAdams, Dam, & Hu, 2007). In addition, the use of the K6 as the measure of emotional distress may have been problematic. The K6 was developed as a screener for mood and anxiety disorders and as such may not be appropriate for determining fine gradients of emotional distress in a nonclinical sample. Finally, this study was conducted with a convenience sample of introductory psychology university students. This population may not be representative of the general population, especially in terms of BMI which has been shown to vary with education level (Molarius, Seidell, Sans, Tuomilehto, & Kuulasmaa, 2000).

Replication of the current study using threatening rather than saddening and disgusting stimuli would test the hypothesis that the stress-buffering effects of romantic relationships are specific to threatening stimuli. Another important extension of this study would involve a longer follow-up period. Fletcher, Simpson, and Thomas (2000) found that 46% of new relationships of university students ended by the 3rd month. While this study successfully predicted which individuals would begin romantic relationships, the maintenance of these relationships was not assessed. Research on the ideal standards model suggest that women with lower mate values (high BMI and/or HRV reactivity) may be less likely to maintain a satisfying romantic relationship (Campbell & Ellis, 2005; Gangestad & Simpson, 2000). Future research addressing the methodological and theoretical issues should be conducted to ensure a comprehensive and valid study of the connection between HRV and romantic relationships.

HRV and BMI were found to interact to affect a woman's likelihood of beginning a romantic relationship. The alternative hypothesis that HRV increases as a result of beginning a romantic relationship was not supported. While the direct replication of Schneiderman's and colleagues' (2011) results failed, their results are not inconsistent with the present study's main finding. Schneiderman's and colleagues' results likely detected pre-existing differences in HRV levels; that is, individuals with higher HRV and low BMI became coupled, and made up the group of new lovers. Therefore, love may not buffer vagal withdrawal in response to stress as postulated by Schneiderman and colleagues. Instead HRV reactivity may be a marker for mate value, and interact with BMI to predict which women are successful in engaging in intermediate- and long-term mating strategies.

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Appendix A

Initial Potential Participant Letter

Dear Potential Participant:

I am a student and research assistant working with Dr. Ron Davis in the Department of Psychology here at Lakehead University. We are conducting a research project called The Love Study. The purpose of this study is to examine the changes in heart functioning that may occur when a person begins a new romantic relationship. This study will follow single women over the course of six months and track physiological and associated psychological changes when they enter romantic relationships. To participate in this study you must be:

- female;
- a non-smoker;
- not currently taking any cold or hypertension medications;
- not currently in a romantic relationship; and
- interested in forming a monogamous heterosexual relationship in the next six months.

If you meet these criteria and are interested in participating in this study, please go to the secure website at https://www.surveymonkey.com/s/TKTVBRL to begin Part 1a of The Love Study.

Participation in this study will involve three components. Part 1a is the online component and involves filling out several questionnaires taking approximately 20 minutes. You will then be prompted to schedule your Part 1b laboratory session. During the laboratory session you will be hooked up to an electrocardiographic (ECG) machine with three sticky electrodes applied to your collar bone and abdomen to record your heart rate, and wear an elastic chest strap to record your respiration rate. You will then watch short film clips while having your heart monitored followed by completing more questionnaires. This first lab visit will be approximately 40 minutes in duration.

Thank you for considering participating in this study.

Sincerely,

Laura Bailey, B.A. (Hons).
Department of Psychology, Lakehead University
E-Mail: lbailey1@lakeheadu.ca
Telephone: 807-707-0102

Dr. Ron Davis, C. Psych., Associate Professor
Department of Psychology, Lakehead University
E-mail: ron.davis@lakeheadu.ca
Telephone: 807-343-8646

Appendix B

Information Letter

Dear Potential Participant:

I am a student and research assistant working with Dr. Ron Davis in the Department of Psychology here at Lakehead University. We are conducting a study called *The Love Study.*

The purpose of this study is to examine the changes in heart functioning that may occur when a person begins a new romantic relationship. This study will follow single women over the course of five months and track physiological and the associated psychological changes when they enter romantic relationships. To participate in this study you must be:

- female;
- a non-smoker;
- not currently taking any cold or hypertension medications;
- not currently in a romantic relationship; and
- interested in forming a monogamous heterosexual relationship in the next six months.

If you meet these criteria and are interested in participating you may continue on with Part 1a of *The Love Study*.

Participation in this study will involve three components. The study begins with an online component and involves filling out several questionnaires taking approximately 20 minutes of your time. You will then be prompted to schedule your first laboratory session. During the laboratory session, you will watch short film clips depicting human relationships and have your heart monitored throughout by electrocardiogram (ECG) with electrodes attached to your right and left clavical, and abdomen. You will also complete more questionnaires, in total taking approximately 40 minutes of your time.

You will be invited to come back for part 2 either a) once you enter into a romantic relationship, or b) after Feb 15, 2013, if you have not begun a romantic relationship. This session will involve the same procedure as the first laboratory session and take approximately 50 minutes. In total, participation in this study will take approximately 60 minutes for the online and first laboratory session, for which you will receive one bonus point toward your Introductory Psychology 1100 final grade, and 50 minutes for your second laboratory session, for which you will receive a second bonus point for that course.

Your participation in this study is completely voluntary and you may withdraw from it at any time without penalty. All information you provide will be kept completely confidential. Only Dr. Ron Davis and research assistants Laura Bailey, Lauren Turner, Chad Keefe, and Jenny Morgan will be permitted to view your information. All of the information you provide will be assigned a code and will be securely stored at Lakehead University for 5 years, as per University regulations. In addition, your identifying information will be kept completely confidential in reports of results and publications.

There are no known physical or psychological risks associated with participating in this study. The films may induce some very transient emotional changes but these are expected to be very brief. This risk should be no greater than what you might normally experience when viewing TV programs or movies within your own environment.

You may choose not to answer any question asked of you without penalty or consequence. Please feel free to contact myself and/or Dr. Ron Davis with any questions that you might have. The Research Ethics Board (REB), which is located in the Office of Research at Lakehead University, has approved this study. If you have any questions regarding this research, feel free to contact the REB at (807) 343-8283.

Thank you for considering participating in this study.

Laura Bailey, B.A. (Hons).
Department of Psychology, Lakehead University
E-Mail: lbailey1@lakeheadu.ca
Telephone: 807-707-0102

Dr. Ron Davis, C. Psych., Associate Professor
Department of Psychology, Lakehead University
E-mail: ron.davis@lakeheadu.ca
Telephone: 807-343-8646

Appendix C

Consent Form

By providing my name and student number below, I indicate that I have read the "Participant Information Letter" and that I have had the opportunity to receive satisfactory answers from the researchers concerning any questions that I might have about my participation. I understand and agree to the following:

1. I understand the information on the "Participant Information Letter";
2. I agree to participate in this study;
3. I am a volunteer and can withdraw at any time from this study without penalty or consequence;
4. I may choose not to answer any question asked in the questionnaires without penalty or consequence;
5. I understand there is a possibility that I may experience transient changes in my mood during the study;
6. My data will remain confidential and will be securely stored in the Department of Psychology at Lakehead University for 5 years, as per University regulations;
7. My information will remain anonymous should any publications or public presentations come out of this study; and
8. I may receive a summary of this research study upon completion of this study if I so request.

[ ] I have read, understand and agree to this "Consent to Participate"

Please provide your information below.

__________________________ __________________________
Full Name (*please print*) Date

____
Signature *(please sign)*

Name of your Introductory Psychology Professor (for purposes of bonus points) :

Psychology 1100 section (YA, YB, or YC) :

Appendix D

Demographics Questionnaire

Demographics Questionnaire: Part A

1. Date: _____/______/______ (DD/MM/YY)
2. Sex: ________
3. Age: ________
4. Ethnic background: (please choose one or more)

Caucasian □

South Asian □

Hispanic □

African-Canadian □

First Nations □

East Asian □

Other □

(please specify):_______________

5. Height in feet and inches (guess if you don't know): ____________
6. Weight in pounds (guess if you don't know): _____________

Demographics Questionnaire: Part B

Motivation 1. Please rate your motivation to begin a monogamous heterosexual romantic relationship on the following scale: ___

0 I do not want to begin a monogamous romantic relationship by Feb 15, 2013

1 I do not care if I begin a romantic relationship by Feb 15, 2013

2 I would like to begin a romantic relationship in the by Feb 15, 2013

3 I intend to begin taking action to begin a romantic relationship soon

4 I am currently taking action to begin a romantic relationship

Motivation 2. Please rate your motivation to begin a monogamous heterosexual romantic relationship by Feb 15, 2013 on the following scale: _____

0 -------- 1 -------- 2 -------- 3 -------- 4 -------- 5 -------- 6 --------7
Not at all motivated Extremely motivated

Expectancy. Please estimate how likely you are to begin a monogamous heterosexual romantic relationship by Feb 15, 2013 using the following scale: _____

0 -------- 1 -------- 2 -------- 3 -------- 4 -------- 5 -------- 6 --------7
Not at all likely Extremely likely

Demographics Questionnaire: Part C

1. Date ___/___/___ (DD/MM/YY)

2. Are you currently in a monogamous heterosexual romantic relationship?

   Yes □

   No □

If you answered *yes* to the previous question please complete the following:

3. When did your current relationship begin? ____/____/_____ (DD/MM/YY)

4. Are you currently in love (please choose one)?

   Yes □

   No □

Appendix E

Rosenberg Self-Esteem Scale

0 = Strongly Disagree

1= Disagree

2= Agree

3= Strongly Agree

1. I feel that I'm a person of worth, at least on an equal basis with others.

2. I feel that I have a number of good qualities. *

3. All in all, I am inclined to feel that I am a failure.

4. I am able to do things as well as most people

5. I feel I do not have much to be proud of. *

6. I take a positive attitude toward myself. *

7. On the whole, I am satisfied with myself.

8. I wish I could have more respect for myself. *

9. I certainly feel useless at times. *

10. At times I think I am no good at all.

* Items are reverse-scored.

Appendix F

Attachment Style Questionnaire

Show how much you agree with each of the following items by rating them on this scale:

1 = totally disagree; 2 = strongly disagree; 3 = slightly disagree; 4 = slightly agree; 5 = strongly agree; 6 = totally agree

1. Overall I am a worthwhile person.	1	2	3	4	5	6
2. I am easier to get to know than most people.	1	2	3	4	5	6
3. I feel confident that other people will be there for me when I need them.	1	2	3	4	5	6
4. I prefer to depend on myself than other people.	1	2	3	4	5	6
5. I prefer to keep to myself.	1	2	3	4	5	6
6. To ask for help is to admit that you're a failure.	1	2	3	4	5	6
7. People's worth should be judged by what they achieve.	1	2	3	4	5	6
8. Achieving things is more important than building relationships.	1	2	3	4	5	6
9. Doing your best is more important than getting on with others.	1	2	3	4	5	6
10. If you've got a job to do, you should do it no matter who gets hurt.	1	2	3	4	5	6
11. It's important to me that others like me.	1	2	3	4	5	6
12. It's important to me to avoid doing things that others won't like.	1	2	3	4	5	6
13. I find it hard to make a decision unless I know what other people think.	1	2	3	4	5	6
14. My relationships with others are generally superficial.	1	2	3	4	5	6
15. Sometimes I think I am no good at all.	1	2	3	4	5	6
16. I find it hard to trust other people.	1	2	3	4	5	6
17. I find it difficult to depend on others.	1	2	3	4	5	6
18. I find that others are reluctant to get as close as I would like.	1	2	3	4	5	6
19. I find it relatively easy to get close to other people.	1	2	3	4	5	6

20. I find it easy to trust others. 1 2 3 4 5 6

21. I feel comfortable depending on other people. 1 2 3 4 5 6

22. I worry that others won't care about me as much as I care about them. 1 2 3 4 5 6

23. I worry about people getting too close. 1 2 3 4 5 6

24. I worry that I won't measure up to other people. 1 2 3 4 5 6

25. I have mixed feelings about being close to others. 1 2 3 4 5 6

26. While I want to get close to others, I feel uneasy about it. 1 2 3 4 5 6

27. I wonder why people would want to be involved with me. 1 2 3 4 5 6

28. It's very important to me to have a close relationship. 1 2 3 4 5 6

29. I worry a lot about my relationships. 1 2 3 4 5 6

30. I wonder how I would cope without someone to love me. 1 2 3 4 5 6

31. I feel confident about relating to others. 1 2 3 4 5 6

32. I often feel left out or alone. 1 2 3 4 5 6

33. I often worry that I do not really fit in with other people. 1 2 3 4 5 6

34. Other people have their own problems, so I don't bother them with mine. 1 2 3 4 5 6

35. When I talk over my problems with others, I generally feel ashamed or foolish.

1 2 3 4 5 6

36. I am too busy with other activities to put much time into relationships. 1 2 3 4 5 6

37. If something is bothering me, others are generally aware and concerned. 1 2 3 4 5 6

38. I am confident that other people will like and respect me. 1 2 3 4 5 6

39. I get frustrated when others are not available when I need them. 1 2 3 4 5 6

40. Other people often disappoint me. 1 2 3 4 5 6

Appendix G

Kessler Psychological Distress Scale

The following questions ask about how you have been feeling during the past 30 days. For each question, please select the circle which corresponds to the number that best describes how often you had this feeling. During the past 30 days, about how often did you feel this way...

0= None of the time 1 = A little of the time, 2 = Some of the time, 3 = Most of the time, 4 = All of the time

1. ...nervous? ______

2. ...hopeless? ______

3. ...restless or fidgety? _______

4. ...so depressed that nothing could cheer you up? _______

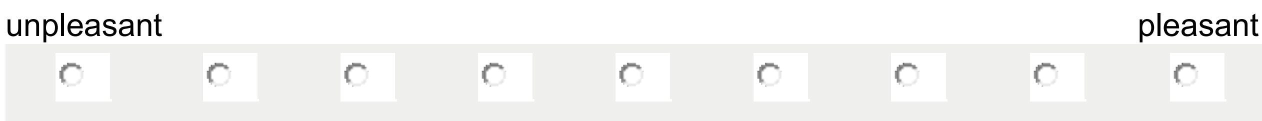
5. ...that everything was an effort? _______

6. ...worthless? _______

Appendix H

Pleasantness Questionnaire

Please use the following pleasantness scale to rate the feelings you had during the film clip.



Appendix I

Passionate Love Scale

Please think of the person whom you love most passionately right now. Keep this person in mind as you complete this section of the questionnaire (The person you choose should be of the opposite sex if you are heterosexual or of the same sex if you are homosexual). Try to tell us how you feel towards that person at the current moment.

Possible responses to each item ranged from:

1	2	3	4	5	6	7	8	9
Not at all true				Moderately true				Definitely true

All of your answers will be strictly confidential.

1. Since I've been involved with ___________, my emotions have been on a roller coaster.
2. I would feel deep despair if ____________ left me. *
3. Sometimes my body trembles with excitement at the sight of _______________.
4. I take delight in studying the movements and angles of _____________'s body.
5. Sometimes I feel I can't control my thoughts; they are obsessively on ____________. *
6. I feel happy when I am doing something to make ___________ happy. *
7. I would rather be with ____________ than anyone else *
8. I'd get jealous if I thought ____________ were falling in love with someone else.
9. No one else could love ____________ like I do.
10. I yearn to know all about _____________. *
11. I want _____________ - physically, emotionally, mentally. *
12. I will love ___________ forever.
13. I melt when looking deeply into ____________'s eyes.
14. I have an endless appetite for affection from _____________.*
15. For me, _____________ is the perfect romantic partner. *
16. _____________ is the person who can make me feel the happiest.
17. I sense my body responding when __________ touches me. *
18. I feel tender toward ___________.
19. _____________ always seems to be on my mind.*
20. If I were separated from _______________ for a long time, I would feel intensely lonely.
21. I sometimes find it difficult to concentrate on work because thoughts of _________ occupy my mind.
22. I want _____________ to know me – my thoughts, my fears, and my hopes. *
23. Knowing that ____________ cares about me makes me feel complete.
24. I eagerly look for signs indicating ____________'s desire for me. *

25. If _____________ were going through a difficult time, I would put away my own concerns to help him/her out.
26. ______________ can make me feel effervescent and bubbly.
27. In the presence of ____________, I yearn to touch and be touched.
28. An existence without _____________ would be dark and dismal.
29. I possess a powerful attraction for _____________. *
30. I get extremely depressed when things don't go right with my relationship with ______.*

Note: The * indicates items selected for the short version of the Passionate Love Scale.

Appendix J

Registering for the Lab Component

You have now finished the online component of the Love Study.

To earn full bonus marks, you need to participate in the laboratory portion of this study. To participate in the Part 1 laboratory portion of this Love Study, click "Done" button and you will be taken to the Experiment Manager web page. There you will:

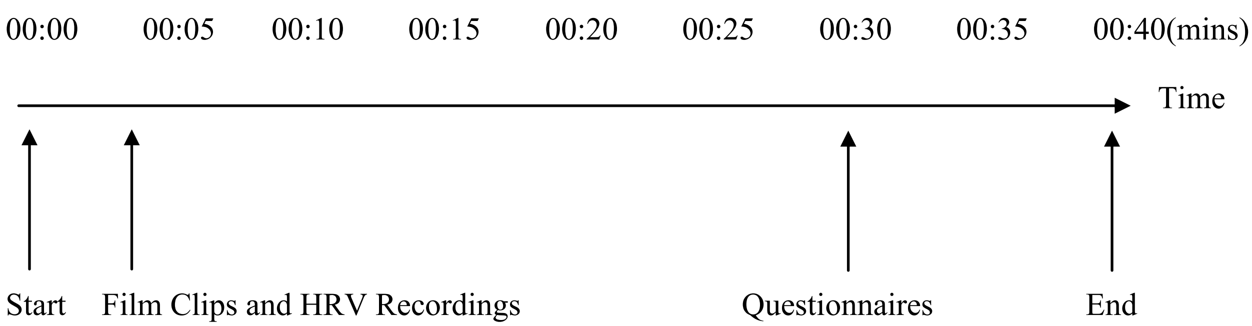
1. Register a new account;
2. Select the "Love: Part 1" to participate in;
3. Select a day and time for you to visit the laboratory in the Department of Psychology to complete Part 1 of the Love Study.

This registration for Part 1 of this study will only take a couple minutes of your time.

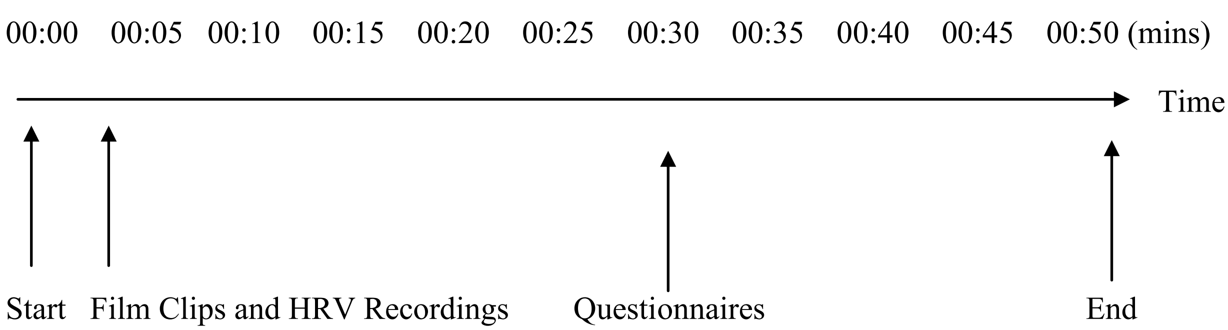
Appendix K

Timeline of Experimental Procedures

Baseline laboratory session



Follow-up laboratory session

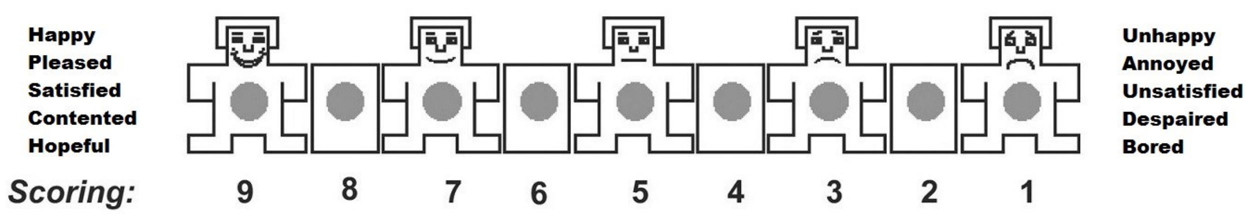


Appendix L

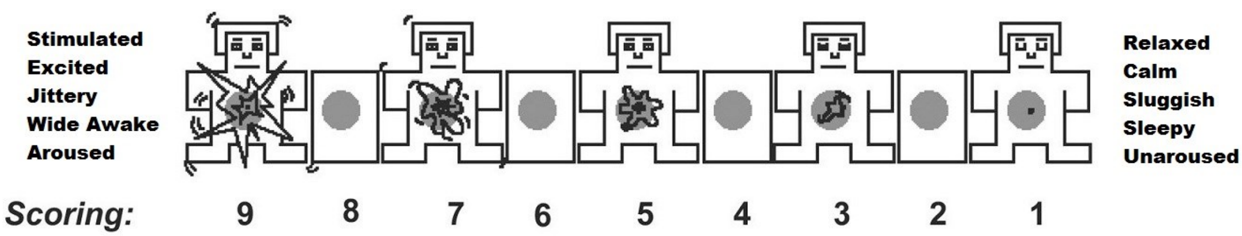
Self-Assessment Manikin

Please rate the clips based on how they make you feel on the following scales:

1. This is the happy-unhappy scale, in which the drawings range from a smiling figure to a frowning figure. At one extreme of this scale, you feel happy, pleased, satisfied, contented, hopeful. If you feel completely happy while viewing the clip, you can indicate this by filling in the bubble in the figure on the left (9). The other end of the scale indicates that you feel completely unhappy, annoyed, unsatisfied, melancholic, despairing, bored. You can indicate feeling completely unhappy by filling in the bubble in the figure on the right (1). The figures also allow you to describe intermediate feelings of pleasure. If you feel completely neutral, neither happy nor unhappy, fill in the bubble in the figure in the middle. If, in your judgment, your feeling of pleasure or displeasure falls between two of the figures, then fill in the circle between the figures. This allows you to make more finely graded ratings of how you feel when viewing the clips.



2. This is the excited/calm scale. At one extreme of this scale, you feel stimulated, excited, frenzied, jittery, wide awake, and aroused. If you feel completely aroused while viewing the clip, fill in the bubble corresponding to the figure at the left of the row (9). On the other hand, at the other end of the scale, you feel completely relaxed, calm, sluggish, dull, sleepy, and unaroused. You can indicate that you feel completely calm by filling in the bubble corresponding to the figure at the right (1). As with the happy/unhappy scale, you can represent intermediate levels by selecting the number which corresponds to the bubble in any of the other figures. If you are not at all excited nor at all calm, fill in the bubble which corresponds to the figure in the middle (5). Again, if you wish to make a more finely tuned rating of how excited or calm you feel, fill in the circle between any of the figures.



Appendix M

Love Study Part 1 Debriefing

Dear Participant:

This sheet gives you a brief summary of the study that you just completed. Please read carefully.

You may have noticed your mood changing while viewing some of the films. Viewing certain thematically related film clips has been shown to induce short-term mood states, and has also been shown to evoke physiological changes such as changes in heart rate. If you experienced any distress during this study please inform the researcher now or contact him or her later using the contact information provided below.

The study you just completed is the first component of a two-part study for single participants. The final component of the study involves a second laboratory session similar to the one you just completed. The second laboratory session will take approximately 50 minutes and you will receive a second bonus point for your Introductory Psychology 1100 final grade. You are invited to schedule your second laboratory session once you meet the following criteria:

- you have entered into a monogamous heterosexual dating relationship; and
- you have been in this relationship for 10 consecutive days.

Once you meet these criteria please email the researchers at lbailey1@lakeheadu.ca to sign up for your second laboratory session. Reminder emails will be sent to you every 28 days. If you do not meet both criteria by February 15, 2013 you will be invited by email to arrange a time to return to the lab for your second session.

If you have any questions about the study, please ask now. If you would like a brief summary of the results of this study please print your LU email address and we will send them to you when available.

Email address:____________________________________

Again, thank you for participating in our study!

Laura Bailey, B.A. (Hons).
Department of Psychology, Lakehead University
E-Mail: lbailey1@lakeheadu.ca
Telephone: 807-707-0102

Dr. Ron Davis, C. Psych., Associate Professor
Department of Psychology, Lakehead University
E-mail: ron.davis@lakeheadu.ca;
Telephone: 807-343-8646

Appendix N

Counselling Resource

If you did experience distress during participation in *The Love Study* please do not hesitate to inform the researchers. You may also wish to contact the following for free counseling services:

Lakehead University Student Health and Counselling Centre (807-343-8361)

Located across from Security, near the Agora and University Centre Theatre. Personal counselling for students covering a wide variety of issues.

Appendix O

Participant Reminder Email

Dear Love Study participant,

Have you entered into a monogamous heterosexual romantic relationship?

Have you been in this relationship for 10 consecutive days?

If you answered YES to the two questions above, I would like to remind you to sign up for Part 2 of the Love Study. Part 2 will take approximately 50 minutes to complete and you will receive a second bonus point toward your Introductory Psychology 1100 final grade. To sign up please go to http://lupsych.sona-systems.com and sign up for the Love Study Part 2.

Thank you for your participation and have a great day.

Sincerely,

Laura Bailey, B.A. (Hons).

M.A. Clinical Psychology Candidate

Appendix P

Love Study Part 2 Debriefing

Dear Participant:

This sheet gives you a brief summary of the study you just completed. Please read carefully.

You may have noticed your mood changing while viewing some films. Viewing certain thematically related film clips has consistently been shown to induce short-term mood states, and has also been shown to evoke physiological changes such as changes in heart rate variability (HRV). HRV refers to the variation between successive heartbeats. Higher HRV indicates a greater ability to cope effectively with stressors.

The current study examines changes in HRV associated with beginning a new romantic relationship. Studies have linked higher HRV with newly coupled individuals. Several other variables that are known to be associated with HRV and relationship status were measured including self-esteem and attachment.

If you experienced any distress during this study, please inform the researcher now or contact him or her later using the contact information provided below. Experimenters will also provide contact information for counseling services upon request. If you have any questions about the study, please ask now. If you would like a brief summary of the results of this study please print your LU email address and we will send them to you when available:

Email address:___________________________________

Again, thank you for participating in our study!

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