# Romantic love modulates women's identification of men's body odors

Johan N. Lundström [a,b,c,*], Marilyn Jones-Gotman [c]

[a] Monell Chemical Senses Center, 3500 Market Street, Philadelphia, PA 19104-3308, USA
[b] Department of Psychology, University of Pennsylvania, Philadelphia, USA
[c] Montreal Neurological Institute, McGill University, Montreal, Canada

## ARTICLE INFO

## ABSTRACT

Romantic love is one of our most potent and powerful emotions, but very little is known with respect to the hormonal and psychological mechanisms in play. Romantic love is thought to help intimate partners stay committed to each other and two mechanisms have been proposed to mediate this commitment: increased attention towards one's partner or deflected attention away from other potential partners. Both mechanisms find support in the literature. We explored the potential influence of each of these mechanisms by assessing women's ability to identify (ID) body odors originating from their boyfriend, a same-sex friend, and an opposite-sex friend and the relationship between this ability and the degree of romantic love expressed towards their boyfriend. We hypothesized that an increase in attention towards one's partner would render a positive correlation between ID of a boyfriend's body odor and degree of romantic love; conversely, we hypothesized that attention deflected away from other potential partners would render a negative correlation between ID of an opposite-sex friend's body odor and degree of romantic love for the boyfriend. Our results supported the deflection theory as we found a negative correlation between the degree of romantic love for the subjects' boyfriends and their ability to ID the body odor of an opposite-sex friend but not of their boyfriend or same-sex friend. Our results indicate that romantic love deflects attention away from potential new partners rather than towards the present partner. These changes are likely mediated by circulating neuropeptides and a testable model is suggested.

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## Introduction

Romantic love is a cross-cultural, universal phenomenon that is believed to have existed since the dawn of mankind and is known to modulate a wide range of human behaviors and emotions (Sternberg, 1986). Romantic love has been demonstrated to elicit widespread changes in basic biological and psychological functions, but experiments on the neurobiology of love are rare in larger animals, and most of the literature focuses on neuroendocrine changes in rodents. In humans, romantic love is known to induce widespread changes in neuroendocrine states (Esch and Stefano, 2005), neurological functions (Aron et al., 2005; Bartels and Zeki, 2004), and overt behavior (Frank, 1988). However, the mediating biological and psychological mechanisms remain unresolved.

The psychological mechanism of romantic love has long been attributed to heightened attention towards one's partner, which in turn leads to heightened feelings of attachment, reward, and commitment (Frank, 1988; Sternberg, 1986). However, at least two separate, yet interconnected, mechanisms are now proposed in the literature (Frank, 1988; Gonzaga et al., 2001): increased attention towards one's partner (here called *attention theory*) or deflected attention away from other potential partners (here called *deflection theory*). The attention theory postulates that an increase in attention towards one's partner leads to an increase in attachment and promotes shared activity and a long-term relationship. This theory is supported by the correlation between reported feelings of romantic love and the increased release of oxytocin (Zeki, 2007), a neuropeptide known to facilitate attachment and bonding (Keverne and Curley, 2004). Moreover, behaviorally, it is commonly reported that intense feelings of love result in a desire to be close to and an obsession with the individual who is the target of these feelings. In contrast, the deflection theory postulates that an increase in passionate love will lead to a decrease in attention towards other potential mates in one's surroundings, which in turn leads to a reduction in relationship threats and aids in the long-term commitment to one's current partner (Miller, 1997). Indeed, individuals engaged in a romantic relationship are known to spend less time observing attractive opposite-sex individuals (Miller, 1997), and their attractiveness ratings of alternative partners are known to be lower than those of unattached controls (Simpson et al., 1986). Romantic love also seems to affect perceptual attention in that individuals in a state of romantic love demonstrate reduced attention to alternative partners at an early and more automated stage of visual perception than do controls

* Corresponding author. Fax: +1 267 519 4690.
E-mail address: jlundstrom@monell.org (J.N. Lundström).

(Maner et al., 2008). There seems to be a clear link between measures of attention and romantic love; however, conflicting evidence exists in the literature regarding the underlying psychological mechanisms.

The ability to recognize an individual could arguably be the foundation for all social relationships, including those between kin, mates, and friends. Whereas it is well known that humans can identify individuals based on visual or auditory cues, e.g., faces or voices, it is not as well known that we are capable of accurately identifying individuals based on odor cues alone (Olsson et al., 2006; Porter and Moore, 1981; Weisfeld et al., 2003). Furthermore, recent findings demonstrate that humans also seem to use odors as an aid in mate selection (Jacob et al., 2002; Ober, 1999; Wedekind et al., 1995). Hence, body odors carry within them information that, among other things, allows the human sensory system to identify the individual emitting them (Lundstrom et al., 2008b; Lundstrom et al., In press). However, in contrast to the identification of an individual based on visual or auditory cues, identification by body odor alone is done with a large degree of underconfidence (Lundstrom et al., 2008b). This under-confidence in our ability to identify an individual based solely on their body odor indicates that one may tap into perceptual abilities with a limited amount of interference from direct conscious recognition. Similar to other sensory modalities, odor identification performance is known to correlate with allocated attention (Murphy et al., 2001; Zelano et al., 2005).

We sought to elucidate the contributing factors behind the two potential mechanisms of romantic love by assessing the ability of human participants to identify individual body odors. We postulated that if romantic love enhances attention towards one's partner, a high degree of romantic love felt towards that partner should enhance the ability to identify that partner's body odor. Conversely, if romantic love focuses attention away from potential rivals, a high degree of romantic love felt towards one's partner should suppress the identification of an opposite-sex friend's, but not same-sex friend's, body odor in heterosexual participants. Here, we address whether a heterosexual woman's ability to identify the body odor of her romantic partner, and that of a male and female friend, is influenced by the degree of romantic love she feels towards her partner.

## Methods

### Participants

Twenty nulliparous, self-described exclusively heterosexual women (mean age: 21 years, SD ± 1.6) participated. Of the participating women, 3 were within 5 days of menstrual onset, 3 were in the follicular phase (days 6–14), and 14 were in the luteal phase (days 15–30) of their menstrual cycle; all women described their menstrual cycle length as stable and within the normal range (mean menstrual cycle length = 28.4 days, range 28–30). In addition to the participants described above, their male partner (mean length of relationship: 26 months) and two close heterosexual friends (mean length of friendship: woman friend 53.6 months, man friend 34.5 months) participated as body odor donors. Only couples that had been together for 12–36 months, were self-described heterosexuals, and had expressed deep romantic love towards each other in a semi-structured interview were included in the study. To control for possible hormonal influences originating from stage of romantic love (Marazziti and Canale, 2004), we selected a time window that was meant to exclude participants who were in the early stage of their relationship and those who had entered a more mature phase of love common in long-term relationships (Diamond, 2004). There was no significant difference in the length of friendship between sex of friends (paired samples Student's $t$-test, $t(19) = 2.19$, $p = 0.07$). Detailed written informed consent was obtained from all participants and the experimental protocol was approved by the McGill University's Human Research Ethics Board.

### Materials and procedures

To collect the body odors, each odor donor slept for seven consecutive nights alone in a cotton t-shirt with odorless cotton nursing pads (Ultra-Thin Nursing Pads, Gerber Inc., On, Canada) sewn into the underarm area and followed instructions regulating their contact with other individuals and pets, personal hygiene, and diet to prevent contamination of the pads (Lundstrom et al., In press). However, to keep the burden of participation to an acceptable level, only tactile contact was prohibited and social contact with body odor donors remained unregulated during the collection week. Prior to insertion of the pads, the t-shirts and any bedding used by the participants were washed with a scent-free wash detergent provided by the experimenters. The t-shirts were stored in a closed zip-locked bag when they were not being worn. T-shirts were returned on the morning of the eighth day, and the pads were removed from the shirts and placed in large-mouthed glass bottles. After behavioral testing, the pads were deep frozen (−80°C) until used. General ability to identify odors was assessed with the Sniffin' Sticks 16-item cued olfactory identification test (Hummel et al., 1997). The Sniffin' Sticks test is comprised of felt-tip pens containing suprathreshold odors, each of which represents an odor object; each pen is presented in conjunction with a cue card listing four labels, and the participants are instructed to select the label corresponding to the odor object.

Ratings of passionate love felt towards the partner were obtained using the Passionate Love Scale (Hatfield and Sprecher, 1986). The Passionate Love Scale consists of 30 statements such as "In the presence of my boyfriend, I yearn to touch and be touched" or "For me, my boyfriend is the perfect romantic partner", and the participant is asked to rate each statement's degree of accuracy with respect to their own feelings towards their boyfriend. The passionate love scale is considered a reliable tool to assess this complex sentiment (Aron et al., 2005; Bartels and Zeki, 2004; Hatfield and Sprecher, 1986).

Ability to identify an individual's body odor was assessed for each body odor category in a three-alternative, no-feedback, forced-choice task with seven trials, using the target body odor and the odors of two same-sex strangers as lures. The body odor collected from the other participants' friends or boyfriends were used as the odors of strangers. Identification of body odors is known to be influenced by perceived intensity (Doty et al., 1982). To allow us to identify potential effects due to this phenomenon, ratings of perceived intensity of each body odor category were obtained using 10 cm visual analog scales (Lundstrom et al., 2008a). All behavioral tests were performed in a counterbalanced order and the true aim of the experiment was revealed to the participants and their body odor donors after completion of the study.

### Statistical analyses

Identification performance above chance for the respective body odor categories was assessed with separate one-sample Student's $t$-tests with chance performance as target value. Potential differences in perceptual ratings were analyzed with repeated measures analyses of variance (ANOVAs) with body odor category as the independent variable, and potential differences between menstrual cycle phases were analyzed with a one-way ANOVA using menstrual cycle phase as a between-groups measure. Potential connections between body odor identification performance and variables of interest were assessed in two ways. First, individual bivariate Pearson correlation analyses were performed for each body odor category. Second, to assess coefficient of determination and whether other collected measures contributed significantly to the relationship between ability to identify a male friend's body odor and degree of love felt towards one's romantic partner, a multiple regression analysis with stepwise exclusion was performed with subsequent correlation analyses. Only two-tailed significance testing was performed and, unless explicitly stated otherwise, all significant results withstood Bonferroni corrections for multiple statistical comparisons.

## Results

The Sniffin' Sticks control task of general odor identification yielded normal scores (above 12) for all subjects (Hummel et al., 2007). Participants could identify above chance the body odor from their boyfriend (mean 5.2), $t(19)=5.48$, $p<0.001$, woman friend (mean 4.7), $t(19)=4.66$, $p<0.001$, and man friend (mean 4.6), $t(19)=3.72$, $p=0.001$. Although one might assume that participants would have greater exposure to their boyfriend's body odor compared to that of

their friends, thus resulting in more accurate identification than for that of their friends, there was no difference between individual odor categories in identification performance, $F(2, 38)=0.38$, $p$ ns., or in intensity ratings, $F(2, 38)=0.39$, $p$ ns., according to repeated-measures ANOVAs. To assess the potential influence of menstrual cycle phase on identification performance, separate exploratory ANOVAs were performed with menstrual cycle phase as a between-groups variable. There were no significant effects due to menstrual phase on identification performance, all $F<0.90$, all $p>0.42$. However, because determining the effect of menstrual cycle phase was not an aim of this experiment, two cells in the ANOVA contained a low number of participants; thus, care should be taken when interpreting these results as a clear negative finding.

Whether a participant's identification performance would be affected by the degree of passionate love felt towards their partner was assessed by correlating body odor identification performance with the score on the passionate love scale using separate bivariate Pearson correlations. There was a significant negative correlation between the ability to identify the male friend's body odor and passionate love felt towards the romantic partner, $r(20)=-0.63$, $p<0.001$ (Fig. 1A). There was no similar correlation for the woman friends' body odor, $r(20)=0.17$, $p$ ns (Fig. 1B), and more importantly, there was no correlation between love felt towards a boyfriend and the ability to identify his body odor, $r(20)=0.01$, $p$ ns (Fig. 1C). To elucidate whether other collected measures significantly contributed to the relationship between ability to identify a male friend's body odor and degree of love felt towards one's romantic partner, a multiple regression analysis was performed. The regression model consisted of performance in identification of the male friend as dependent variable, and ratings of love, length of friendship with male friend, length of relationship with partner, perceived intensity of the male friend's body odor, and ability to identify general odors served as independent variables. Although this model resulted in a significant relationship, $r(5, 14)=0.74$, $p<0.03$, $r^2=0.55$, this result did not withstand Bonferroni correction. Stepwise regression analysis revealed that of the variables included in the regression model, the sole variable contributing significantly was the obtained scores on the romantic love scale, $r(1, 18)=0.63$, $p<0.003$, $r^2=0.40$.

Additionally, we explored whether length of possible exposure to the individual body odors was mediating the effects by correlating identification performance with length of either romantic partnership or friendship. There was no significant correlation between identification performance and partnership duration, $r(20)=0.31$, $p$ ns, or of friendship duration with either friend, man, $r(20)=0.29$, $p$ ns, or woman $r(20)=-0.40$, $p$ ns. Moreover, there were no significant correlations between the general ability to identify odors, as indicated by the 16-item olfactory identification test, and identification performance in any of the three body odor categories, all $p>0.83$.

## Discussion

The main aim of the experiment was to explore the relationship between romantic love and the ability to identify individuals based on body odor as a means of dissociating between the attention theory and the deflection theory. In line with the deflection theory, the degree of romantic love a woman feels towards her partner is related to her ability to identify her opposite-sex friend's body odor but not to identification of the body odor of her same-sex friend or boyfriend. The more in love with their boyfriend participants reported themselves to be, the worse they performed in identifying the body odor originating from an opposite-sex friend — a potential partner for these heterosexual women.

There was no relationship between degree of expressed romantic love and identification performance for the body odor originating from a same-sex friend. This indicates that the demonstrated effect is sexual preference-specific. Similar findings were recently reported in
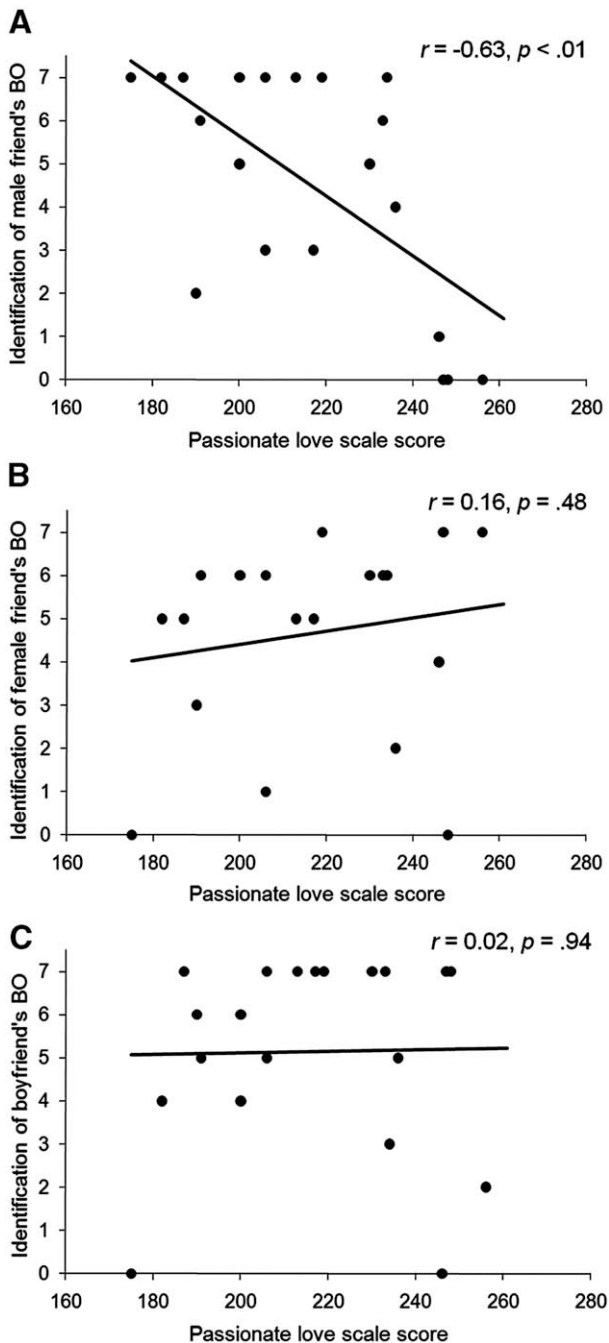
Fig. 1. Relationships between obtained subjective rating of romantic love felt towards their boyfriend (max score=300) and identification performance (max score=7) of respective individuals. (A) Relationship between participants' ability to identify their male friend's body odor (BO) and rated degree of romantic love; (B) relationship between participants' ability to identify their female friend's body odor and rated degree of romantic love; (C) relationship between participants' ability to identify their boyfriend's body odor and rated degree of romantic love. Solid line in each graph marks the regression line. Inference statistics given in each graph are the strength of the correlation between the two variables, as measured by a bivariate Pearson correlation.

the visual system; individuals in a romantic state demonstrated a reduced attention to opposite-sex individuals but not to same-sex individuals (Maner et al., 2008). Although comparisons between studies and sensory modalities are difficult to make, the apparent similarities seem to indicate a modality independent decrease in attention towards potential additional partners, specifically, and not towards individuals in general. Clear sex differences are known to exist in the processing of body odors. Whereas it has been repeatedly demonstrated that women are able to extract genetic information from men's body odors to aid in mate selection (Jacob et al., 2002; Lundstrom et al., 2008c; Wedekind et al., 1995), men do not seem to possess this capacity (Santos et al., 2005). However, because only women were tested in this study to reduce the potential variance caused by the known sex differences in olfactory performance (Doty et al., 1984), we are unable to address the question of potential sex-specific effects with the current data set.

The negative correlation between identification of an opposite-sex friend and degree of love, together with the lack of relationship with identification of a boyfriend's body odor, supports the deflection theory. However, it is possible that both psychological mechanisms are at play and act in conjunction with each other, but acting at different time points. Behavioral studies on various forms of attention support the deflection theory (Gonzaga et al., 2001; Maner et al., 2008; Miller, 1997; Simpson et al., 1986), whereas neuroimaging (Bartels and Zeki, 2004; Fisher et al., 2005) and neuroendocrine studies (Carter, 1998; Marazziti and Canale, 2004) support the attention theory. Although the data presented here implicate the deflection theory, we acknowledge that the sample size is small and a larger population based study would provide a more definitive demonstration. However, that the effect is strong even in a small sample size indicates the robustness of the phenomena. Moreover, as discussed above, it is very much conceivable that such a complex emotion as romantic love is modulated by more than two mechanisms.

Romantic love is intimately reciprocally linked to the endocrine system; specifically, oxytocin and vasopressin are associated with romantic love (Esch and Stefano, 2005; Marazziti and Canale, 2004) and their receptors are found throughout the olfactory system (Carter, 1998). Whereas oxytocin is known to modulate attachment behavior and feelings of trust, vasopressin is known to affect social recognition (Bielsky and Young, 2004), attention (de Wied et al., 1991), memory (Engelmann et al., 1996), and partner selection in other animals (Cho et al., 1999). The structural similarities of oxytocin and vasopressin enable each to bind to the other's receptors (Bielsky et al., 2005), which complicate analysis of their respective effects on behavior (Esch and Stefano, 2005). However, a key regulator of vasopressin in the brain is the hypothalamic area (Ferris and Delville, 1994) where lesions are known to greatly reduce a female ferret's approach and award salience towards body odors emitted by a male conspecific (Robarts and Baum, 2007). In light of this and other recent connections between vasopressin and social recognition (Bielsky et al., 2005), we postulate that the reduced ability to identify a potential partner demonstrated by participants reporting a high degree of love felt towards their partner is mediated by elevated levels of oxytocin. Increased levels of the fast-acting oxytocin would deplete available oxytocin and vasopressin receptors, thereby decreasing levels of bound vasopressin. The subsequent drop in acting vasopressin would lower the capacity for olfactory social recognition by reducing the salience of an opposite-sex individual's body odor and also a decrease in selective attention as demonstrated in animal studies (Robarts and Baum, 2007). In addition, the increased uptake of oxytocin would lead to heightened feelings of attachment towards the partner, giving this suggested mechanism an increased survival value as a behavioral modulator since it would act on two separate systems (Carter, 1992). This hypothetical mechanism that we propose could be verified in future studies by measuring the uptake of oxytocin and vasopressin levels in relationship to the degree of romantic love by means of receptor-labeled imaging.

To conclude, the negative correlation between ability to identify the body odor of opposite-sex friends and the degree of romantic love expressed towards a boyfriend seem to indicate that romantic love deflects attention away from potential new partners. The sex-specificity of this effect is demonstrated by the lack of a similar correlation for the body odor of same-sex friends. It is likely that these behavioral outcomes are mediated by underlying changes in levels of bound neuropeptides.

## Acknowledgments

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