

An Examination of Olfactory Ability and Adult Attachment Styles

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Research (Human Sciences)

Declaration of Originality

The works found within this thesis are original and have not been submitted for publication, written by another person, nor submitted for a higher degree to any other university or institution. The empirical research contained within this thesis was conducted for the Masters of Research (Human Sciences) program and approved by the Human Research Ethics Committee at Macquarie University (reference number: HREC 5201600167).

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Abstract

Olfaction is the oldest sense in humans yet remains the least researched and least understood of the five senses. The olfactory system is most typically thought to be important only for its practical functions in smell and taste. However, olfaction researchers overwhelmingly agree that this chemosensory sense is much more sophisticated than these basic functions. Recent research has begun to explore the role of olfaction in social functions such as emotions and relationships. The thesis aimed to investigate the previous research on olfactory functioning with respect to its role and influence in social contexts, and highlight the key social areas where olfaction has been implicated. The literature review examined previous olfaction research in order to highlight the importance of this sensory system, then present research that points to the role of olfaction in facilitating relationships. The empirical study focused on olfactory ability and, in particular, its relationship with adult attachment styles. Participants ($N = 80$) completed a series of questionnaires measuring attachment and relationship styles, empathy, and psychological wellbeing (DASS-21). In addition, participant evaluated the significance of their sense of smell, and completed three olfactory tasks (Sniffin Sticks) that test odor threshold, discrimination and identification ability. Empirical findings are presented and discussed with respect to existing research. This is the first study to specifically study olfactory ability and attachment. Given the robust links between olfaction, emotions and relationship factors, more research is needed in this area in order to gain a better understanding of the influence of olfaction in social relations.

“Smell is a potent wizard that transports you across thousands of miles and all the years you have lived. The odors of fruits waft me to my southern home, to my childhood frolics in the peach orchard. Other odors, instantaneous and fleeting, cause my heart to dilate joyously or contract with remembered grief. Even as I think of smells, my nose is full of scents that start awake sweet memories of summers gone and ripening fields far away.”

— **Helen Keller** *US blind & deaf educator (1880 - 1968)*

Literature Review:

The Importance of Olfaction in Social Communication, Emotions and Relationships

Despite the olfactory system being the oldest sense in humans, it remains the least researched and least understood of the five senses. Vision, and to a lesser extent audition, have received the majority of research attention in recent decades. While it is readily accepted that humans rely heavily on their visual sense, olfaction researchers unequivocally agree that the sense of smell is far more remarkable than previously realized and its dominance in several key areas of human functioning has been greatly underestimated (de Groot et al., 2012; Stevenson, 2010). The sense of smell is most typically thought to be important only for its practical functions such as influencing nutritional behavior (e.g., detecting palatable, good-tasting foods and avoiding poisonous and/or spoiled foods), directing attention towards environmental pleasures (e.g., perfumes, fresh flowers, newborns) and avoiding environment hazards (e.g., dangerous fumes, fires, toxins, microbial threats; Croy, Nordin, & Hummel, 2014; Croy, Symmank, et al., 2014; Schaal, 1988; Stevenson, 2010). However, recent research interest in the olfactory system is revealing that this chemosensory sense is actually much more sophisticated than these basic practical functions.

The Importance of Olfaction as a Basic Sensory Mechanism

In a recent evaluation of human olfaction, Stevenson (2010) summarized the major functions of the olfactory system into three main categories (a) ingestion (detection/identification of food items), (b) avoiding environmental hazards (commonly sparked by elicitation of emotions such as fear and disgust), and (c) social communication. According to Stevenson (2010), social communication comprises three main categories: Social interpersonal functions (olfactory communication that includes olfactory recognition, bonding and intimacy); reproductive functions (inbreeding avoidance, detection of prospective mates via attraction and mate-selection); and socio-emotional functions (emotional implications such as emotional contagion, olfactory comfort and stress buffering).

Close inspection of the literature reveals several studies have identified important links between olfaction and many ‘socio-functions’ such as quality of life (Croy, Nordin et al., 2014), psychological health (Croy, Symmank et al., 2014), emotions (Hatfield, Cacioppo, & Rapson, 1993), and close relationships (Chalouhi et al., 2005; Herz & Inzlicht, 2002; Mallet & Schaal, 1998). It is this most recent appreciation of olfactory functioning—as a mechanism facilitating social landscapes and interactions—that has opened an avenue of exploration that is progressively and rapidly elucidating the full scope of this phenomenal sense.

Olfactory Development and Functioning: From the Womb to the Tomb

The olfactory system develops early (Chalouhi et al., 2005). Olfactory bulbs form a definitive structure by around the 56th day of gestation (Chalouhi et al., 2005) and by around 4-6 months post-conception the nostrils of the fetus open (Winberg & Porter, 1998). As a result, even before birth, a human fetus is exposed to many odorous molecules via the amniotic fluid (Schaal, Marlier, & Soussignan, 2000; Winberg & Porter, 1998). Since olfaction is functional during prenatal life, it is not surprising that researchers have found infants are born with extremely efficient olfactory abilities (Chalouhi et al., 2005). From an evolutionary perspective, an efficient olfactory system in infancy is not only advantageous but essential for survival (Makin & Porter, 1982; Porter, Makin, Davis, & Christensen, 1992). In one study, newborns were found to show odor preferences and could discriminate between odors within hours of birth (Russell, Mendelson, & Peeke, 1983). Moreover, research has shown that infants are attracted to and can discriminate their mother’s scent and breast milk from odors of other mothers (Badiee, Asghari, & Mohammadizadeh, 2013).

Olfaction is not only crucial in infancy but remains important during the first years of development as children grow and their environmental and social relationships increase (Chalouhi et al., 2005; Ferdenz, Coureaud, Camos, & Schaal, 2008). Unfortunately, studies in this early age group (e.g., toddlers to pre-pubescent) have been relatively sparse compared to that of infants (Chalouhi et al., 2005). Nevertheless, research suggests that children similarly

exhibit a keen olfactory ability and that 6-10 year olds can analyze and describe their chemosensory environments (Ferdenz et al., 2008). Moreover, a keen olfactory ability may be necessary during childhood as research suggests children rely on olfactory cues to find and discriminate between familiar and unfamiliar persons as they extend their social networks (Chalouhi et al., 2005). In a study by Mallet and Schaal (1998), they found that school children aged 9- to 10-years could identify their classmates by smell alone and that this accuracy was higher for the recognition of same-sex classmates. Mallet and Schaal (1998) also found girls, but not boys, were better at recognizing the body odor of their preferred rather than their non-preferred class acquaintances. Mallet and Schaal theorized that this may be because females are generally more olfactory-oriented than males, and that female friendships are typically more intimate than male friendships. These findings are in line with other research that suggests olfactory sensitivity increases more for girls than for boys during puberty (e.g., Doty et al., 1984; Ferdenz et al., 2008). The reasons for this difference between the genders is not yet clear but research nevertheless suggests that the sexes typically maintain this pattern and that females continue to have better overall olfactory ability compared to males across adulthood numerous studies reporting that females overwhelmingly outperformed males in a variety of smell tests (e.g., Chen & Haviland-Jones, 2000; Croy, Nordin et al., 2014; Hummel & Nordin, 2005; Stevenson, 2010). The reasons for this are not yet fully understood, though it is postulated that perhaps this divergence in olfactory sensitivity during pubescent years may be because of the more important role olfaction will play in the coming years for women (e.g., attachment, intimacy and reproductive strategies) compared to males.

According to Doty et al. (1984), after infancy, peak olfactory performance occurs between ages 30 to 50 and begins to decline rapidly at age 70. Deterioration of olfactory functioning is very common in the older population; being present in over half of those aged 65 and 80 years (Doty et al., 1984). Such olfactory dysfunction has been shown to

significantly negatively impact physical wellbeing and quality of life by compromising nutritional intake, food enjoyment, and everyday safety. Further, olfactory dysfunction has also been implicated as a key factor in a range of degenerative cognitive processes, as well as neurological and neuropsychiatric disorders (Croy, Nordin et al., 2014; Hummel & Nordin, 2005; Negoias et al., 2010).

Olfactory Deficits: Serious Implications for Physical and Emotional Health

Research investigating the implications of olfactory deficits illustrates that olfaction is extremely important in everyday life, not only for its smelling functionality but for a range of physical, cognitive and emotional outcomes. According to Croy, Nordin, et al. (2014), olfactory disorders are common and affect about 20% of the general population. Olfactory disorders can range from total inability to detect odors (anosmia), to decreased ability to detect odors (hyposmia), or even a distorted perception of odors (dysosmia; Miwa et al., 2001; Stevenson, 2010). Common causes of olfactory loss include birth defects, respiratory infection, nasal/sinus disease, and head injuries (Croy, Nordin et al., 2014; Miwa et al., 2001). Not only are olfactory deficits more prevalent than often realized, but the implications of olfactory deficits are associated with a range of negative physical, psychological and psychosocial consequences (Croy, Nordin et al., 2014; Hummel & Nordin, 2005).

One of the most apparent consequence associated with olfactory deficits is related to the primary functions of the olfactory system, namely smelling and tasting. The loss of the sense of smell has been linked to changes in eating behavior such as reduced enjoyment of food, diminished appetite, inadequate nutritional intake, and weight loss or gain (Deems et al., 1991; Miwa et al., 2001). Individuals have also reported difficulties with regard to cooking-related hazards including inability to detect spoiled or burnt food, and restricted awareness of environmental hazards such as smoke, gas leaks, or fires (Hummel & Nordin, 2005; Miwa et al., 2001).

However, several studies have found that the consequences of olfactory deficits extend well beyond the implications associated with the basic functions of smelling and eating. Olfactory disorders have been linked to a range of degenerative processes. For instance, decreased olfactory ability can be an early sign of neurodegenerative diseases such as Alzheimer's disease (Moberg et al., 1987) and Parkinson disease (Doty, 2012). Findings from these studies report that these individuals demonstrate poorer performance in detection, discrimination, and identification of odors compared with age-matched controls (Doty, 2012; Moberg et al., 1987). Further, neurological diseases such as Huntington's disease (Moberg et al., 1987) and epilepsy (Hummel et al., 2013) have been linked to hyposmia. Hyposomia has also been observed in individuals with neuropsychiatric disorders, including acute major depression (Croy, Symmank, et al., 2014), schizophrenia (Moberg et al., 1999), and seasonal affective disorder (Negoias et al., 2010). Neurodevelopmental disorders have also been linked to olfactory disorders. For example, Cecchini et al. (2016), found severe olfactory impairment (anosmia) in persons with Down syndrome, while Bennetto, Kushner, and Hyman (2007) found children aged 10-18 years with autism performed significantly worse on the Sniffin Sticks odor identification task than matched controls. Notably, olfactory dysfunction has also been found to be a predictor of increased risk of mortality. In a study of more than 3,000 participants aged 57 to 85, Pinto, Wroblewski, Kern, Schumm, and McClintock (2014) found 39% of individuals who failed a simple smelling test had died within five years. In fact, they found olfactory dysfunction was better at predicting mortality than heart failure, cancer or lung disease and thus concluded that olfactory function (or dysfunction) is one of the strongest predictors of 5-year mortality (Pinto et al., 2014).

Individuals with olfactory impairments also report personal and social implications. Among the most common are mood changes such as increased anxiety (Krusemark, Novak, Gitelman, & Li, 2013) and depression (Croy, Symmank et al., 2014) and increased feelings of vulnerability (Deems et al., 1991). More specifically, individuals with olfactory impairment

are excessively anxious about personal hygiene due to the inability to detect their own (unpleasant) body odor and bad breath (Hummel & Nordin, 2005; Miwa et al., 2001). Reduced olfactory functioning has also been linked to social problems including, reduced social relations, social pleasure and social life (Herz & Inzlicht, 2002), and increased problems at work (Lehrner, Kirchebner, Auff, & Pusswald, 2015). Similarly, olfactory impairment has been found to impact intimate sexual relations (Gudziol, Wolff-Stephan, Aschenbrenner, Joraschky, & Hummel, 2009). Individuals, and particularly men, with reduced olfactory functions often report reduced sexual appetite and a generally impaired sex life (Gudziol et al., 2009). Conversely, individuals who report or demonstrate olfactory impairments also express a reduction of general life satisfaction, overall health and psychological quality of life, (Croy, Nordin et al., 2014; Deems et al., 2001; Hummel & Nordin, 2005; Miwa et al., 2001).

In sum, the existing research indicates that olfactory disorders are associated with a broad range of negative physical, psychological and psychosocial outcomes. However, it is important to note that these limitations have not just been observed in clinical samples. Research suggests that normal people can also suffer from some degree of olfactory impairment and may not be aware. While Croy, Nordin et al. (2014) contend that olfactory disorders are common, it is suggested that it is equally common for olfactory loss or decreased olfactory ability to go unnoticed (Hummel & Nordin, 2005). In most cases, olfactory loss deteriorates gradually, consequently it may be years before symptoms present and individuals become aware of olfactory impairment (Hummel & Nordin, 2005). Given the implications associated with reduced olfactory functioning, it is particularly worrying that olfactory loss generally goes undetected in everyday life by many individuals and thus warrants further investigations.

Social Interpersonal Functions: The Role of Olfaction in Facilitating Relationships***Social Communication: The Role of Chemosignals in Human Behavior***

It is a commonly accepted assumption that human communication occurs almost exclusively via language and visual cues (de Groot et al., 2012). However, several researchers (e.g., de Groot et al., 2012; Frumin et al. 2015; Jacob & McClintock, 2000; Stern & McClintock, 1998; Stevenson, 2010) assert that humans also communicate through smell. Specifically, it is proposed that humans, like many animals, communicate with each other via chemosensory signals (de Groot et al., 2012; Jacob & McClintock, 2000). Chemosignals are airborne chemicals released by an individual and received by another inter-species member, subsequently affecting the physiology or behavior of the receiver (de Groot et al., 2012). In fact, there are suggestions that the olfactory system has such fine-tuned receptors that even imperceptible scent molecules are processed by the brain outside of conscious awareness (de Groot et al., 2012; Frumin, 2015; Gelstein et al., 2011). Indeed, it is argued that the majority of socio-olfactory information transmitted and received from others is conveyed and acquired this way (de Groot et al., 2012).

The premise that chemosignals have the ability to modulate human behavior was suggested after it was demonstrated that women living together developed synchronized menstrual cycles (e.g., de Groot et al., 2012; Stern & McClintock, 1998). Conversely, this particular claim has been somewhat contentious with some researchers suggesting it has not been well supported in subsequent literature (e.g., Stevenson, 2010). Nevertheless, there is mounting evidence that support the socio-communication perspective that posits chemosignal communication is continually occurring, consciously and unconsciously, in human's social interactions (e.g., de Groot et al., 2012; Jacob & McClintock, 2000; Stern & McClintock, 1998). For example, Gelstein et al. (2011) asked 24 males to sniff odorless female tears. They found that, for men, merely sniffing negative-emotion-related female tears resulted in reduced sexual appeal and attraction towards women's faces, as well as a reduction in testosterone

levels, self-rated and physiological sexual arousal, and decreased activity in brain substrates relating to sexual arousal (Gelstein et al., 2011). In a more recent study, Frumin et al. (2015) found that participants who engaged in structured greetings that involved handshaking were more likely to overtly sniff their own hand afterwards compared to those who engaged in a greeting with no handshake. They concluded that humans are not only exposed to chemosignals but that they often actively search for them (Frumin et al., 2015). Although Frumin et al. did not propose that the sole function of handshaking behavior is to gather olfactory information via social chemosignals, they did theorize that social chemosignaling may be an instinctive motivator for handshaking (or physical contact) behavior. Certainly, there may be communicative significance from engaging in this type of behavior. For example, a study by Wallace (1977) found that adults were able to discriminate between two persons based only on odors emitted from the palm of their hand.

Social Communication: The Role of Chemosignals in Human Emotions

The idea that humans communicate via chemosensory signals is not only limited to the modulation of human behavior (de Groot et al., 2012). According to Keltner and Haidt (1999) emotions are important dynamic processes that mediate how an individual relates to a continually and rapidly changing social environment. It has been well-documented that animals (from invertebrates to fish to mammals) can communicate their emotional states (such as anger and fear) through changes in their body odor (e.g., Nault, Montgomery, & Bowers, 1976; Todd, Atema, & Bardach, 1967). However, more recent research has found that the theoretical framework of the social and emotional communication via chemosignaling perspective can be extended to humans (Chen & Haviland-Jones, 2000; de Groot, 2012; Hatfield et al., 1993; Krusemark et al., 2013). This process, also referred to as “emotional contagion”, describes the subliminal synchronization of an emotional experience between sender and receiver (de Groot, 2012; Hatfield et al., 1993) This emotional contagion enables the sender to communicate emotions—indicating beliefs and intentions—to another thereby

altering the affective, perceptual and behavioral response of the receiver. According to researchers, emotional contagion optimizes chances of survival because emotions evoked in others can elicit desired behavioral outcomes such as affiliation, soothing, helping or avoidance (de Groot et al., 2012; Hatfield et al., 1993; Keltner & Haidt, 1999).

Several studies have investigated the phenomenon of chemosignaling in humans and found evidence to suggest that human body odors carry information that indicates emotional states. For example, Chen and Haviland-Jones (2000) collected underarm odors from 25 women and men participant donors while viewing either a funny or frightening movie excerpt—on two separate consecutive days. They then invited 77 women and men one week later to correctly identify the emotion state associated with the odor presented (happy, fearful or neutral). Chen and Haviland-Jones found that women were often able to correctly identify the happy odor from happy-induced participant donors, and that men could also correctly identify happy-induced odors, but only when the odors were from female donors. Participants were also able to correctly identify fear from the fear-induced odor pads from male but not female fearful donors. Thus, Chen and Haviland-Jones (2000) concluded that human body odors can and do transmit signals that communicate emotional states to others. In a more recent study, de Groot et al. (2012) tested the theory that emotional contagion serves as a motivator to elicit an appropriate response. In this study, de Groot et al. (2012) collected sweat samples from men while watch fear- or disgust-evoking movie scenes. They found women who were exposed to chemosignals from fear-induced men produced fearful facial expressions, while women who were exposed to chemosignals from disgust-induced men produced disgusted facial expressions (de Groot et al., 2012). The authors concluded that exposure to an emotion chemosignals of the sender elicited a reproduction of that specific emotion in the receiver (de Groot et al., 2012). Taken together, these findings provide robust evidence to support the theory that human body odor carries information that communicates emotional states that facilitates social relationships. This notion of emotional contagion via

chemosensory signaling also introduced an exciting new complexity to how we understood the way in which humans perceive and interact with one another (Chen & Haviland-Jones, 2000).

Odors Promote Identification and Recognition of Human Kin

The olfactory system has also been found to play a key role in relationships by facilitating interpersonal connections via chemosensory signaling that promote olfactory cues for identification and recognition of loved ones and kin (Mallet & Schaal, 1998; Vaglio, 2009). The olfactory system is particularly salient for infant identification and mother recognition (e.g., Badiie et al., 2013; Porter et al., 1992). Odors are crucial for infants, especially within the first few weeks of their lives when they are the most vulnerable (Schaal, 1988). Having limited resources, infants rely on olfactory cues for feeding and identifying their mothers (Makin & Porter, 1989; Porter et al., 1992). As mentioned earlier, infants are born with an incredibly efficient olfactory system. Research has found that newborns are immediately attracted to their mothers' smell (Badiie et al., 2013; Porter et al., 1992). In one notable study, 30 women who had just given birth immediately had only one of their breasts washed while the other remained unwashed, and when their newborns were placed on their chest, the majority of the infants oriented their head towards the unwashed breast (Varendi, Porter & Winberg, 1994). This odor recognition appears to be mutual with research demonstrating that mothers can also identify their own infants by smell alone as little as 6 hours after birth, even after only a single exposure to the newborns odor (Russell et al., 1983). Infants, are also able to discriminate their mothers' smell from others persons. For example, breast-feeding infants between postnatal days 4-15 were found to prefer the odor of their mothers' breast odor to the breast odor of an unfamiliar lactating mother (Makin & Porter, 1989; Porter et al., 1992). Taken together, these results demonstrate that infants are equipped with an olfactory system that is wired to instinctively search for and recognize its mother, and facilitate mother-infant bonding (Vaglio, 2009). This identification-recognition function

between infant and mother provides an evolutionary advantage that promotes infant survival during this critical period (Vaglio, 2009).

Odor identification and recognition is salient for mother-infant interactions, however the ability for humans to recognize and discriminate their kin and loved ones from strangers via odors and chemosignals continues into adulthood. Adults and children appear to be remarkably good at discriminating their kin from non-kin by body odor (Porter & Moore, 1982; Weisfeld, Czilli, Phillips, Galls, & Lichtman, 2003). For example, children aged 5 to 8 years could identify their 3-4 year-old siblings from unfamiliar age-matched children via their odor alone (Porter & Moore, 1981). Similarly, Porter and Moore (1981) likewise found adults could distinguish their siblings from age- and sex-matched strangers by odor. Additionally, parents could also recognize their offspring from a control child (Porter & Moore, 1981); however, neither mothers or fathers have been found to be particularly good at discriminating between their own children (Weisfeld et al., 2003).

Several researchers have proposed that the ability to recognize kin by odor developed as an evolutionary mechanism in an effort to eradicate incest during childhood and avoid inbreeding (Porter & Moore, 1981). Several lines of research support this contention. For example, Weisfeld et al. (2003) found mothers were able to identify their biological children by odor but not their stepchildren. Likewise, children were able to recognize their full siblings by olfactory cues but not their half- or step-siblings (Weisfeld et al., 2003). Weisfeld et al. also found children were able to recognize their opposite-sex siblings but not their same-sex siblings. Particularly noteworthy is evidence that suggests that parent-child olfactory recognition goes beyond the use for identification. For example, fathers showed a significant aversion for their daughters odor while mother preferred the odor of a control child over her own children, though did not appear to have a particular odor aversion to either their sons or daughters (Weisfeld et al., 2003). Collectively, these findings suggest that odor identification

and recognition in kin relationship can promote familiarity but may also serve as an internal forewarning for genetically inappropriate (sexual) relations.

In sum, humans emit detectable natural odors that transmit information that may be useful for promoting social relationships with others (Mallet & Schaal, 1998). These studies suggest that children, adults and parents store in their long-term memory the odors of loved and familiar ones. According to Porter and Moore (1981), this function is complex and takes into consideration gender, phenotypic matching, and familial associations. Importantly, odor identification and recognition may serve as an important olfactory function in social relations. First by facilitating familial relationships, and second by eliminating the potential for incestual relations during childhood as well as ensuring inbreed avoidance (Porter & Moore, 1981).

Odors and Reproductive Functions: Attraction and Mate Selection

Another important identified function of olfaction, particular body odor, is in reproductive strategies. Research suggests that explicit odors and implicit chemosignals play a particularly important role in attraction and mate selection. For instance, in a study by Herz and Inzlicht (2002) women ranked “how a man smells” as the most important physical characteristic when selecting a mate. In fact, women considered a man’s “smell” to be more important than “looks” or any other social or personal factors, with the exception of general pleasantness (Herz & Inzlicht, 2002). Moreover, despite evolutionary theories that suggest women seek out potential mates with good recourses, Herz and Inzlicht (2002) found that women valued body odor of a potential partner considerably higher than money or resource potential. Men similarly rated natural body odor as an important prerequisite for sexual interest, though they still rated “looks” as the most important requirement for attraction (Herz & Inzlicht, 2002). Nevertheless, it appears that body odors are important to women and men when it comes to attraction and mate selection, but to different extents. In another study, Lundström and Jones-Gotman (2009) investigated the role of body odor in the context of

romantic love in women. They found that the higher the degree of romantic love women reported for their present boyfriend/partner, the poorer they were at identifying the body odor of an opposite-sex friend but not of their boyfriend or a same-sex friend. Lundström and Jones-Gotman (2009) proposed a *deflection theory*, in that the role of olfaction in romantic love is not to increase attention and sensitivity towards the present partner's odor but instead to deflect attention away from any potential partners (i.e., opposite-sex friends).

Several studies indicate that females are generally more olfactory-orientated than males and it is theorized this is to assist females in their mate-selection strategies whereby women seek out “good” genes in potential partners (Thornhill & Gangestad, 1999). In other words, the olfactory system as a mechanism works to subconsciously guide attraction towards evolutionary appropriate mates, especially for women seeking men (Herz & Inzlicht, 2002). For instance, women tend to regard masculine (i.e., “relative unpleasant”) body odor with positive masculine values, such as “active”, “strong”, and “athletic” (McBurney, Levine, & Cavanaugh, 1976). Other research has found that women prefer the odor of physically symmetrical men, especially during ovulation (Thornhill & Gangestad, 1999). A major theory is that the Major Histocompatibility Complex (MHC) genotype is central to mate-selection strategies (Wedekind, Seebeck, Bettens, & Paepke, 1995). MHC refers to surface cell proteins or genotypes that mediate interaction with different immune cells in order to recognize foreign molecules in others (Mahmut, Stevenson, Stephen, Fitness, & Case, in press).

The MHC theory is supported by numerous studies that have shown women report a clear preference for the scent of men with MHC profiles that are complementary to their own (i.e., different profile) indicating different immune systems (e.g., Mahmut et al., in press; Wedekind et al., 1995). For example, Wedekind et al. (1995) found females preferred the odor of t-shirts worn by men whose MHC differed from their own. From an evolutionary perspective, pairings with dissimilar immune profiles are likely to have offspring that are more heterozygous and hence better immunity. Such unions would ensure a healthier gene

pool in successive generations (Jacob & McClintock, 2000; Mahmut et al., in press). Moreover, it is theorized that this function evolved, not only to optimize offspring survival, but to avoid incest and inbreeding (Jacob & McClintock, 2000; Thornhill & Gangestad, 1999). Wedekind's (1995) findings have been replicated in several studies thereby providing robust support for the theory that "good" genes and body odor dominate women's mate-selection strategies is valid (Hertz & Inzlicht, 2002; Jacob & McClintock, 2000; Thornhill & Gangestad, 1999).

While it is clear that olfaction plays a crucial role in attraction and mate selection, it is still a relatively young area of research and warrants further investigation. Notably, the majority of these studies have used random male participant odors rather than odors from male partners of female participants. Furthermore, most existing studies on body odor in mate selection have used armpit odor; yet other areas of the human body similarly convey smells that may aid in social communication but have gone largely unexplored, including, neck, hair, forehead, wrists, forearms, and genitalia.

Socio-Emotion Functions

Olfaction and Emotions and Emotional Memory

The olfactory sense has a unique intimacy with emotional processing due to neural connectivity. Unlike other senses, olfactory neuroanatomy is intertwined with primary emotion areas including the amygdala, hippocampus, and orbitofrontal cortex (OFC; Negoias et al., 2010; Stevenson, 2010). Stimulation of the olfactory bulbs can directly activate amygdala neurons, bypassing the primary olfactory cortex, before arriving at the secondary (association) olfactory cortex situated in the middle of the OFC (Negoias et al., 2010; Stevenson, 2010).

Given that olfactory and emotional processing share common neural structures it is not surprising that several lines of research findings have shown that odors are easily able to alter mood, affect (Jacob & McClintock, 2000), and feelings of comfort (McBurney, Shoup &

Streeter, 2006). Generally, odors perceived as pleasant induce positive affect whereas odors perceived as unpleasant induce negative affect (Krusemark et al., 2013; Porcherot et al., 2010). This, coupled with the fact that the influence of odors on emotions can in turn lead to alterations of thoughts, behaviors and physiological responses, suggests that odors have a powerful ability to create positive or negative experiences (Croy, Olgun, & Joraschky, 2011; Lombion-Pouthier, Vandel, Nezelof, Haffen, & Millot, 2006;).

Odor is also powerful elicitor of emotional memories (Croy et al., 2011; Porcherot et al., 2010). For example, for many people the smell of popcorn evokes vivid memories or movie theatres (or childhood experiences) while the smell of disinfectants and medicines bring back fearful or painful memories of being sick or hospitals. Not only can particular odors trigger autobiographical memories, but olfactory memories can be especially emotionally laden (Herz & Cupchik, 1995; Porcherot et al., 2010). In addition to evoking the memory, the odor may elicit the emotional response associated with the memory such as feelings of happiness, fear or unpleasantness (Herz & Cupchik, 1995). Odors readily condition to emotions. For example, Sullivan and Toubas (2011) presented infants with a citrus odor whilst they were gently being stroked on the cheek. Later, they presented the odor without the tactile accompaniment and observed that the infants responded and oriented towards the odor (Sullivan & Toubas, 2011). Odors also have the powerful ability to spark off vivid emotional autobiographical memories (Herz & Cupchik, 1995; Porcherot et al., 2010). Moreover, after an odor has been associated with an emotional experience, it is able to evoke the associated emotional response when encountered later without the odor (Herz & Cupchik, 1995).

Olfactory Comfort: Odors Promote Feelings of Comfort and Reduce Distress

Another important social function of the olfactory system is the behavior of olfactory comfort. Olfactory comfort refers to the practice of “comfort smelling” whereby individuals smell the clothing of significant others’ during periods of separation in order to provide

comfort and relieve experiences of anxiety and loss (McBurney et al., 2006; Shoup, Streeter, & McBurney, 2008). Moreover, McBurney et al. (2006) suggest this practice is a very common behavior. In the study by McBurney et al. (2006), 87% of women and 56% of men admitted to smelling their partners' clothing in order to feel comforted or closer to him/her. It was further found that 72% of women admitted to sleeping with their partners' clothing compared to only 27% of men who admitted doing this (McBurney et al., 2006). This data suggests a gender difference, namely that women engage in the practice of olfactory comfort more so than do men. However, a subsequent study by Shoup et al. (2008) did not replicate the gender differences. They found 77% and 66% of females and males respectively, reporting they engaged in olfactory comfort to "feel good" or "be closer to him/her" (Shoup et al., 2008). The practice of comfort smelling has similarly been reported among family members (Shoup et al., 2008). For instance, children have reported smelling their parents clothing when they were away or after they have died (McBurney et al., 2006). Shoup et al. asked participants if they had ever intentionally smelt or slept with clothing of a kin member. Approximately 30% of women and 15% of men reported doing this with a first degree relative. Shoup et al. (2008) concluded that the practice of comfort elicited by olfactory cues is not limited to sexual or romantic partner but has benefits for any important intimate relationships. The authors concluded that olfactory comfort is beneficial in so far as a sense of comfort is evoked merely by odor that hints to the memory of the physical presence of the other significant person, even when that person is not physically there (McBurney et al., 2006; Shoup et al., 2008).

Studies have also demonstrated that infants similarly not only require "contact comfort" via attachment (Bowlby, 1969) but also seek olfactory comfort. For instance, previous research has revealed that infants have an odor preference for [their mothers'] amniotic fluid and breast milk (Badiie et al., 2013; Makin & Porter et al., 1989) and that these odors have been shown to have a calming effect on infants (Varendi, Christensson, Porter, &

Winberg, 1998). For instance, Varendi et al. (1998) measured crying time of infants that has been separated from their mothers and found that the infants exposed to their mothers' amniotic fluid smell cried significantly less than babies exposed to breast or no odor. Thus they concluded that maternal odor soothes distressed infants as evidenced by reduced crying (Varendi et al., 1998). In a more recent study, Badiie et al. (2013) randomly assigned 50 preterm infants to either breast milk odor or formula milk odor condition. Infants were exposed to the odor for up to nine minutes prior to having a heel prick (a blood screening test performed on newborns). Badiie et al. found premature infants exposed to their odor of their mother's breast milk were measured as experiencing significantly reduced pain and stress compared to infants exposed to formula milk odor. Taken together, these findings provide strong evidence to support the theory that humans seek for olfactory comfort by intentionally seeking odor cues from loved ones in order to feel comforted and reduce anxiety in times of separation (Badiie et al., 2013; McBurney et al., 2006; Shoup et al., 2008). An extension of olfactory comfort is the concept of "attachment objects", such as a favorite blanket, soft toy or cloth that can absorb odors (Ferdenzi et al., 2008; Passman & Weisberg, 1975; Schaal, 1988; Winnicott, 1969). Ferdenzi et al., (2008) suggest that the self-odor left on attachment odors can have soothing and reassuring effects during times of emotional distress or in stressful situations. Further, Winnicott (1969) described this attachment object as having a weaning and transitional function during the separation period of mother and child when the child begins to explore new settings without physical attachment to the mother. Essentially, this theory suggests that the child's self-odor on the attachment object may have similar soothing and reassuring effects on the child as maternal odor did for them in infancy (Ferdenzi et al., 2008). In turn, this physical contact has a positive effect on the child's development of emotional regulation in stressful situations (Ferdenzi et al., 2008; Schaal, 1988).

Passman and Weisberg (1975) exposed blanket-attached and non-blanket-attached 3-year-old children to a novel play setting. Blanket-attached children showed no distress and

explored and played just as much as non-blanket-attached children who had their mothers present. However, when the mothers were removed and the children were left with blanket and toys, the blanket-attached children continued to show the same explorative and playful behavior whereas the non-blanket-attached showed distress and less explorative and play behavior (Passman & Weisberg, 1975). These findings support the idea that a familiar object may act as a replacement comforter and soother, allowing the child to develop some independence and begin to face different and stressful situations without physical attachment to mother. It has been theorized that an attachment object reduces stress by acting as a transitional function during the separation between mother and child (Ferdenzi et al., 2008; Passman & Weisberg, 1975).

Literature Review: Summary

The above literature review has demonstrated the robust several social functions that have found to be associated with olfaction. Moreover, emerging evidence is elucidating the remarkable functions of olfaction as a sensory mechanism and its dominance in several key areas of human socialization. For instance, this literature review has explored previous that has found olfaction is crucial in emotions (e.g., emotional contagion, chemosensory signaling), relationship (e.g., bonding, attraction) and general psychological wellbeing. Moreover, olfactory deficits have been implicated in several serious health problems. Given broad scope of this phenomenal sense, further research investigating its function in social domains is especially crucial given the known implications associated with reduced olfactory functioning and its common prevalence in the general population.

AN EMPIRICAL INVESTIGATION:**Adult Attachment Style and Olfactory Ability**

Humans are fundamentally social beings (Fitness, 2015). From birth, humans enter a social environment wrought with relationships and social interactions with others; making social relations the core of human experience (Fitness, 2015). Humans are innately wired to connect with each other and are dependent upon one another, not only for their physical survival but for their psychological health and overall wellbeing (Fitness, 2015). Like many species, humans begin forming social bonds from infancy and this drive for human connection continues through adolescence, adulthood, and old age (Chalouhi et al., 2005; Fitness, 2015). According to Fitness (2015) failure to form social bonds can result in several negative physical, social and emotional consequences. Fortunately, evolution has equipped humans with the necessary mechanisms required to bond with others and survive in this social world. These mechanisms include (1) the basic human senses of sight, sound, taste, touch and smell, and (2) emotions (Fitness, 2015).

The senses and emotions are profoundly powerful; providing humans with vital information and cues about their social environments (de Groot et al., 2012; Haidt & Keltner, 1999). The senses—sight, sound, taste, and touch—relay information from external stimuli via the thalamus to the orbitofrontal cortex for processing (Chen & Haviland-Jones 1999; Deem et al., 1991; Negoias et al., 2010; Stevenson, 2010). In contrast, the sense of smell has a unique link to emotions, in that the same neural structures involved in olfaction are also involved in emotions (e.g, Chen & Haviland-Jones 1999; Hatfield, Cacioppo, & Rapson 1993; Jacob & McClintock, 2000). In other words, projections from the olfactory tract are relayed directly to the limbic system—the emotion centre of the brain (Negoias et al., 2010). Thus, it is not surprising that olfaction and emotions have been found to be intrinsically linked and both they are both implicated as playing a profound role in relationships.

“From the Cradle to the Grave”: Relationships are at the Core of Human Experience

The Infant-Caregiver Bond

Humans are wired to connect with one another and this instinct is apparent from birth (Fitness, 2015). From the moment an infant is born and placed in its mothers' arms, the process of social bonding begins. With limited abilities, newborns rely on olfactory cues to identify their mothers (Makin & Porter, 1989; Porter, Makin, Davis & Christensen, 1992; Varendi et al., 1994). Infants are born with extremely efficient olfactory abilities and immediately recognize and are attracted to their mothers' smell (Sullivan & Toubas, 1998; Varendi et al., 1994). This recognition appears to be reciprocal. Russell et al., (1983) found mothers could identify their own infant by smell alone within hours after birth. The process of identification and recognition facilitates the infant-mother that is crucial to the infants' physical survival healthy emotional development (Badiee et al., 2013; Belsky, 2002; Bowlby, 1969; Fitness, 2015; Makin & Porter, 1989; Russell et al., 1983; Sullivan & Toubas, 1998).

Attachment Theory

The unique bond between infant and mother is known as Attachment Theory (Bowlby, 1969). The theory of attachment emerged out of Harlow's (1971) seminal work with infant rhesus monkeys whereby he investigated the mechanisms by which newborn rhesus monkeys bond with their mothers (Harlow, Harlow, & Suomi, 1971). In this pioneering work investigating comfort and socialization, Harlow separated rhesus monkeys from their mothers immediately after birth and gave them access to two surrogate "wire" mothers. One of the surrogate wire mothers had milk and the other was covered in soft terry toweling cloth but had no milk. Harlow observed that the infant monkey preferred to spend time with the cloth mother and would only go to the wire mother to feed (Harlow et al., 1971). Once fed it would return to the cloth mother where it would spend most of the day. Harlow proposed that this demonstrated and infants' the need for "contact comfort" and that this was more essentially more important to the survival of the infant than more physical needs (i.e., food). Further, when the infant monkey was presented with a frightening object, Harlow observed that it

sought protection from the cloth mother. Harlow concluded that the need to seek comfort facilitated the bond between infant and mother, and that this was essential to the psychological health development of the infant monkey (Harlow et al., 1971). In other words, infants need interaction and a “safe base” to which they can cling during the first critical months of life (Harlow et al., 1971).

Bowlby (1973; 1980) agreed with Harlow’s (1971) premise that there was much more to the mother-infant relationship than feeding, and argued that the mother was also an essential source of emotional and physical comfort for the human infant. The work by Harlow was the basis for Bowlby’s (1973; 1980) attachment theory. Broadly, attachment theory refers to the unique bond between the infant and primary caregiver (traditionally, but not always the mother) whereby the infant attaches to another who provides the infant with a sense of safety, comfort and stability; subsequently positively influencing the child’s physical, mental and emotional development (Bowlby, 1969; 1973; 1980). According to Bowlby, the infant-caregiver attachment bond is defined by following behavioral observations (1) *proximity maintenance*: the behavior by which the infant seeks physical proximity to the attachment figure; (2) *safe haven*: the behavior by which the infant seeks comfort from the attachment figure at times of distress; (3) *separation distress*: the degree distress when separated from the attachment figure, and (4) *secure base*: the degree to which the infant utilizes the attachment figure as a basis from which to explore safe environments (Bowlby 1969; 1973; 1980; Hazan & Diamond 2000). Since Bowlby first introduced the concept of attachment theory it has received extensive support from researchers who assert, with overwhelming agreement, that attachment is a vital component of an infants’ normal psychological, emotional and social development that have long-term implications (e.g., Belsky, 2002; Fagundes, 2012; Fitness, 2015; Hazan & Diamond, 2000, Hazan & Zeifman, 1999; Mikulincer & Shaver, 2005; Passman & Weisberg, 1975; Shaver & Mikulincer, 2006; Simpson et al., 2011; Wei, Russell, & Zakalik, 2005).

An Explanation of the Infant Attachment Styles

Attachment an important part of socialization (Ainsworth, Blehar, Waters & Wall, 1978; Bowlby, 1969; 1973; 1980; Harlow, 1971). Human infants learn through the relationship with their attachment figure, (a) the extent to which they are valued, protected, and loved, and (b) the extent to which others are caring, comforting and trustworthy (Fitness, 2015). If all goes well, caregivers provide a caring nurturing safe haven for the infant. This early attachment relationship is the source of the infant's first and most powerful experiences of love, trust, safety and happiness (Fitness, 2015). Ideally, the child should be in a loving and secure attachment relationship with a "secure" attachment figure who is able to provide love, comfort and care for the infant. In turn, the infant learns that they fundamentally loved, cared for, valued and protected (Fitness, 2015). However, not every attachment relationship follows this secure descriptive and develops in this secure way. Some attachment figures are inconsistent, harsh, or neglectful. As a result, infants learn from this relationship experience that they are fundamentally unsafe, uncared for, and unloved (Fitness, 2015; Mikulincer, Sheffi, 2000; Mikulincer & Shaver, 2005; Shaver & Mikulincer, 2006).

Ainsworth and colleagues (e.g., Ainsworth et al., 1978) provided early experimental support for the theory of different types of attachment styles. Ainsworth (1978) observed infant-caregiver interactions in accordance with Bowlby's (Hazan & Diamond, 2000) the interaction behaviors outline by Bowlby (1969; 1973; Proximity maintenance; safe haven; separation distress; and secure base. Ainsworth and colleagues (e.g., Ainsworth et al., 1978) developed the "Strange Situation" paradigm to observe the interaction between infant-caregiver in order to determine the nature of attachment behaviors and different styles of attachment. The procedure comprised the of the following process: (1) Mother, baby and experimenter (lasts less than one minute). (2) Mother and baby alone. (3) Stranger joins mother and infant. (4) Mother leaves baby and stranger alone. (5) Mother returns and stranger leaves. (6) Mother leaves; infant left completely alone. (7) Stranger returns. (8) Mother

returns and stranger leaves (Ainsworth et al., 1978). This procedure was designed to determine the degree of attachment security. Using this paradigm, Ainsworth observed one- to two-year-olds as they interacted with the mother, their behavior and level of distress upon separation from their mother, their behavior when left alone and in the presence of a stranger, and, finally, their response to the mother when reunited. Based on the observations of these infant-caregiver interactions Ainsworth concluded there were three different types of attachment styles: Secure, anxious/ambivalent, and avoidant (Ainsworth et al., 1978).

According to Ainsworth's three-category model (Ainsworth et al., 1978), infants that have had attachment experience characterized by love, support and trust have a secure base from which to seek comfort, care and protection when needed thus develop a secure attachment style. In contrast, infants that have typically had early attachment experiences that were inconsistent and tumultuous, have a base that is chaotic, unstable and unsafe thus develop an anxious/ambivalent attachment style (Ainsworth et al., 1978). Finally, infants that have had attachment experiences with harsh, dismissive and neglecting parental styles develop an avoidant attachment style (Ainsworth et al., 1978). Importantly, research suggests that these childhood experiences and attachment styles, not only impact childhood development, but also play a powerful role in shaping future relationships (Bowlby, 1969; Fagundes, 2012; Fitness, 2015; Hazan & Diamond, 2000; Hazan & Shaver, 1987; Mikulincer & Sheffi, 2000; Shaver & Mikulincer, 2006).

Attachment theorists suggest that, as a result of early attachment experiences, individuals derive an "attachment schema"—an implicit belief or theory—about themselves and about what to expect from others in relationships (Fitness, 2015; Hazan & Shaver, 1987; Shaver & Mikulincer, 2006). As individuals enter into adult relationships, they do so with these pre-existing and implicit cognitive beliefs that influence their thoughts, emotions, motivations, appraisals, expectations, and behaviors (Feeney & Kirkpatrick, 1996; Fitness, 2015; Griffin & Bartholomew, 1994; Hazan & Shaver, 1987). Several researchers agree that

the way people behave, perceive, and respond to others in adult relationships derives almost exclusively from their attachment histories and from what they have subsequently learned from relationship experiences, both explicitly and implicitly (e.g., Bowlby, 1969; Feeney, & Kirkpatrick, 1996; Fitness, 2015; Griffin & Bartholomew, 1994; Hazan & Shaver, 1987; Wei et al., 2005). Early attachment experience is one of the most direct predictors of an individuals' implicit cognitive theories with regard to relationships in adulthood (Fitness, 2015; Shaver & Mikulincer, 2006). There is now a large body of research on both the development and impact of "attachment schemas" in adult relationships that leaves little doubt that any impediments during the attachment process that obstruct the bond between infant and caregiver lead to several consequences (Griffin & Bartholomew, 1994; Shaver & Mikulincer, 2006; Wei et al., 2005; Winterheld, 2011).

From Infant to Adult Attachment

Bowlby (1969) famously stated that attachment is not only critical in infancy but essential across the lifespan, "from the cradle to the grave". Fraley and Spieker (2003) concurred that the attachment system essentially functions throughout the lifespan, although the underlying motivations and observable behaviors between infant and adult attachment would perhaps differ. Put simply, adult attachment was conceptualized as an extension of infant attachment and refers to the way an individual acts, feels, and behaves in close, primarily romantic, relationships (Hazan & Shaver, 1987). Hazan and Shaver (1987) maintain that the main components of infant attachment – proximity maintenance, safe haven, separation distress, and secure base – could be similarly be observed in adult relationship patterns. In fact, the response to separation or loss of the romantic figure (protest-despair-detachment) often replicates responses observed during infant-caregiver separation (Hazan & Diamond, 2000). This, according to Hazan and Shaver (1987), was evidence that the bonds (and associated behaviors) between adult romantic partners paralleled those of the infant-caregiver attachment system. Indeed, it is easy to view the accompanying attachment

behaviors of infants and adults as fairly comparable. Hazan and Shaver further argued that the underlying attachment system functions in essentially the same way throughout the lifespan, even though the observable behaviors of infants and adults would clearly differ (Fraley & Spieker, 2003). For example, in infancy, attachment may be crucial for infant survival whereas adult attachment may further be an evolutionary strategy to promote or pair bonds thus promoting reproductive strategies (Hazan & Zeifman, 1999).

Models of Adult Attachment

Hazan and Shaver (1987) developed a model of adult attachment that replicated Ainsworth's (1978) three-category model of infant attachment (i.e., secure, anxious/ambivalent and avoidant attachment). Bartholomew and Horowitz (1991) later examined the motivations underlying the three attachments and found that the categories were motivated by different underlying behaviors. Specifically, they noted different feelings and motivations that were driving the avoidant category. They conceded that even though all avoidantly attached individuals were distrustful of others and viewed others as unreliable, avoidant individuals differed with regard to their core feelings of self-worth (Bartholomew & Horowitz, 1991). Therefore, Bartholomew and Horowitz concluded that the avoidance category should be divided into two distinct categories – Fearful and dismissing – to more specifically reflect the underlying belief systems. Therefore, their final model comprised four attachment categories (see Figure 1; Bartholomew & Horowitz, 1991). This model is generally considered as the most accurate understanding of attachment styles and has been utilized and validated in more than 62 countries (Schmitt, et al., 2004). Moreover, self-ratings of adult attachment generally corroborate with those ratings from peers and family (Griffin & Bartholomew, 1994).

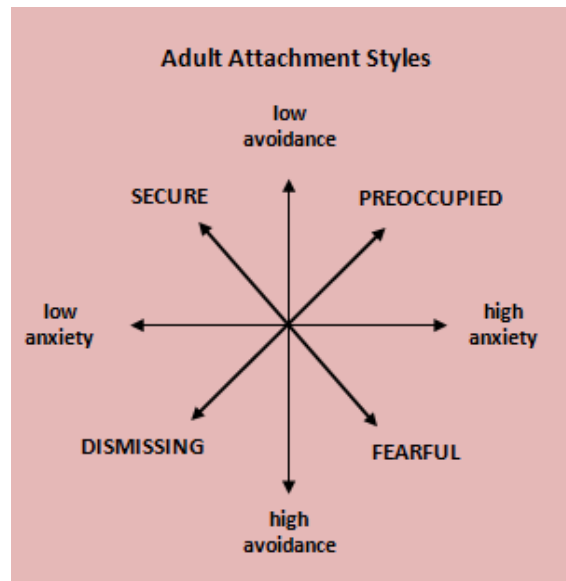


Figure 1. Bartholomew and Horowitz's (1991) four-category model of Adult Attachment

Adult Attachment Styles Defined

Secure adult attachment style: describes individuals that believe that they are valuable and lovable; thus have an internalized sense of self-worth (Bartholomew & Horowitz, 1991). Secure adults typically characterize their romantic experiences as happy and trusting, and view their relationship partners as trustworthy. As such, they are more apt to use their partners as a source of comfort (Feeney & Kirkpatrick, 1996). They are comfortable with intimacy in close relationships and are able to accept and give support in the relationship (Feeney & Kirkpatrick, 1996). They are well equipped to solve relationship problems constructively and to effectively manage difficult emotions such as anxiety or anger. In times of distress, secure adults will attempt to deal with their anxious feelings but are comfortable seeking help when it is needed. (Feeney & Kirkpatrick, 1996; Fitness, 2015).

Preoccupied adult attachment style: is underscored by an anxious attachment approach and describes individuals who are characterized as anxious, consistently seeking to gain acceptance and validation from others (Hazan & Shaver, 1987). They persist in the belief that they could attain safety, or security, if they could only get others to respond appropriately (Fraley & Shaver, 2000). They typically describe their relationship experiences as obsessive, including extreme sexual attraction on the one hand and extreme jealousy on the other

(Sbarra, 2006). Preoccupied adults hope that they will be loved and cared for, yet they equally expect that they will be abandoned (Sbarra, 2006). As a result, they tend to become very anxious and clingy in times of distress and are hyper-vigilant for signs of rejection (Fraley & Shaver, 2000; Sbarra, 2006). They are also apt to appraise ambiguous behaviors as hostile, and frequently experience strong feelings of anger, hurt, and anxiety (Fitness, 2015). In turn, the emotions trigger negative responses and behaviors such as angry retaliation, extreme clinging, or other dependent-type behaviors that further damage their relationships and push people further away (Fraley & Shaver, 2000; Sbarra, 2006). Preoccupied individuals tend to score higher on anxiety measures in comparison to the other attachment styles and have also been associated with clinically significant levels of anxiety sensitivity (Watt, McWilliams, & Campbell, 2005).

Fearful adult attachment style: is underscored by an avoidant attachment approach and describes individuals that are highly dependent on others' acceptance and require constant affirmation (Hazan & Shaver, 1987). Due to previous negative relational experiences they hold negative expectations of others' and typically view others as unreliable and untrustworthy (Fraley & Shaver, 2000). Accordingly, they avoid intimacy to avoid the potential pain of loss or rejection. Fearful adults characterize their relationships as jealous and going from high and low emotional extremes. In times of distress, fearful individuals become very anxious and withdrawn (Feeney & Kirkpatrick, 1996; Hazan & Shaver, 1987). Fearful individuals score higher on anxiety measures and are more often associated with clinically significant levels of anxiety sensitivity (Watt et al., 2005).

Dismissing adult attachment style: is underscored by an avoidant attachment approach and describes persons who avoid closeness to protect themselves from further pain as a consequence of previous negative relationship experiences (Hazan & Shaver, 1987). They have the expectations that others are basically untrustworthy (Hazan & Shaver, 1987). They maintain a false sense of self-worth by defensively and emphatically denying the value of

close relationships (Bartholomew & Horowitz, 1991). They characterize their relationships as jealous, fearful of intimacy and having extreme emotional highs and lows. They have learned from previous relationship experience that others' cannot be relied upon for support when it is needed (Hazan & Shaver, 1987). Therefore, they expect that relationship partners will be rejecting and unhelpful. Dismissing individuals value self-reliance above all. Therefore, in times of distress, they repress their anxiety and avoid emotional closeness, instead relying on their own self-reliance (Feeney & Kirkpatrick, 1996).

Adult Attachment Styles: Support Seeking and Rejection Behaviors

It is also important to consider how attachment orientations differ in regards to other relationship behaviors such as support seeking and empathic behaviors, as well as emotional responses to relationship breakdowns. Predictably several researchers have found that securely attached individuals are able to acknowledge their own distress and turn to others for comfort and support (Belsky, 2002; Fagundes, 2012; Hazan & Diamond, 2000; Hazan & Shaver, 1987). Moreover, they are able to accept and give support in the relationship (Belsky, 2002). In contrast, preoccupied individuals focus on the source of their distress in an effort to elicit the response they want but fear is not forthcoming (Hazan & Shaver, 1987; Mikulincer & Shaver, 2005). Given this, Sbarra (2006) findings that, compared to less anxiously-attached individuals, high anxiously-attached individuals had greater difficulty recovering from post-breakup feelings of loss and sadness. Moreover, anxiously attached individuals are more likely to become overwhelmed with negative emotions of loss/rejection in response to relationship threat (Mikulincer & Shaver, 2005). Interestingly, preoccupied individuals become more empathic when experiencing relationship threat (Simpson et al., 2011). In another study, Fagundes (2012) found that reflecting on painful emotions following breakup was associated with poor emotional adjustment immediately after the breakup regardless of attachment security. However, individuals higher on attachment anxiety suffered greater maladaptive outcomes from these reflections one month later (Fagundes, 2012). In contrast,

avoidant individuals reduce their empathic in times of relationship threat (Simpson et al., 2011). Moreover, dismissing individuals typically do not acknowledge being upset about relationships issues and instead avoid the situation or deal with it themselves rather than seek support from others (Mikulincer & Shaver, 2005). Such emotional distancing and lack of empathic concern means that avoidantly-attached individuals miss out on the rewards of both giving and receiving comfort and support.

Romantic Relationship: Passionate Love versus Attachment Love

Hazan and Shaver (1987) were the first to conceptualize the attachment process in romantic love. Some researchers have identified at least two distinct types of love which frequently co-occur within so-called romantic love relationships: Passionate love and attachment love (e.g., Fitness, 2015; Hatfield, Bensman, & Rapson, 2012). Passionate love is described as the intense longing for a physical and emotional coming together with another (Hatfield et al., 2012). As the primary function of passionate love is to motivate reproductive behaviors, the experience of this love style is driven by strong desires for sexual connection. Attachment love, on the other hand, has derived from the infant-caregiver attachment system that evolved to bond infants to caregivers (Galinha, Oishi, Pereira, Wirtz, & Esteves, 2014; Hazan & Shaver 1987). Attachment love extends beyond the mating functions of passionate love and instead motivate pair-bonds and promote offspring potential (Hazan & Shaver 1987). Ultimately, it is attachment love that keeps people together, long after the initial desire and passion has faded (Fitness, 2015). Attachment love provides feelings of comfort and warmth (McBurney et al., 2006) and facilitates trust, intimacy and relationship happiness (Fitness 2015; Galinha et al., 2014).

The Triangulation of Relationships, Emotions and Olfaction

The Interplay of Emotions and Olfaction

According to Fitness (2015), an important consideration of the emotion-relationship connection is the extent to which an individual understands the features and functions of emotions, as well as having the ability to clearly express their own emotions and to recognize

and empathize with others' emotions. Such emotion knowledge derives from childhood relationships where individuals learn about the causes and consequences of emotions such as anger, fear, and love from their attachment figures, families and wider social networks (Fitness, 2015). In other words, it is during childhood that individuals learn about how they feel, how other people may feel, and what typically causes different emotions and emotional responses (Fitness, 2015; Keltner & Haidt, 1999). Thus, it can be said that appropriate emotion regulation facilitates adaptive relationship functioning and promotes emotional synchronicity and tranquility within the social relationship through to adulthood.

Like attachment schemas, it has been suggested that "emotion scripts or schemas" may similarly operate at a subconscious level; influencing relationship interactions and outcomes (Fitness & Fletcher, 1993). In other words, how individuals understand emotions and what they and others' feel. Emotional expressions such as sadness, anger and love communicate others' needs and desires and allow for the reciprocal fulfillment of such needs (Fitness & Fletcher, 1993). This process, in turn, facilitates relationship intimacy and connection (Fitness & Fletcher, 1993). Silvia (2008) noted that happiness promotes attachments to people, objects and experiences as it signifies that they have proved enjoyable and rewarding in the past. Similarly, the emotion of joy maintains social bonds by evoking the urge to play and have fun, which in turn builds and strengthens friendships and attachment relationships (Fitness, 2015). According to Fitness (2015) these two similar yet distinct emotions frequently co-occur especially in the early stages of a relationship when dyads are experiencing joy and happiness as they play, laugh, and share intimacies together as they get to know each other.

Emotions are dynamic processes that mediate an individual's internal and external response to a continually changing social environment (Keltner & Haidt, 1999). It is widely accepted that odors can influence affect and modulate cognitions and behaviors (Pollatos et al., 2007). Several studies have found evidence to support the premise that odors are easily

able to alter emotions and affect (e.g., de Groot et al., 2012; Frumin et al., 2015; Pollatos et al., 2007; Porcherot et al., 2010), as well as promote feelings of comfort and reduced distress (Badiie et al., 2013; McBurney et al., 2006). Likewise, emotional state has been found to influence odor perception. In one study Pollatos et al. (2007) found participants in a negative emotional state – evoked by negative pictures – rated unpleasant odors more intense compared to participants in a neutral emotional state. Odors are also salient cues to memory and have the powerful ability to instantly generate vivid emotional memories (McBurney et al., 2006). For example, for many people the smell of popcorn can instantly trigger memories of festivals or movie theatres while the smell of disinfectants or medicines can instantly generate memories of hospitals or being sick (McBurney et al., 2006). Not only do odors trigger autobiographical memories, but olfactory-triggered memories are notably more emotionally laden whereby the memory is often simultaneously accompanied by the emotional response associated with that memory such as feelings of happiness, fear or unpleasantness (McBurney et al., 2006). These findings are with previous research that has shown olfaction projects directly to the amygdala which is also the part of the brain that is intimately involved with emotional memory (Pollatos et al., 2007; Stevenson, 2010).

Two Levels of Olfactory Processing: Primary and Secondary Levels of Olfaction

Olfaction researchers also make clear a distinction between a primal and cognitive olfactory system. Researchers suggest that the olfactory system comprises a primary olfactory system that is involved in sensory processing—the way by which humans perceive and interact with odors in the environment, and a secondary olfactory system that is involved in higher order cognitive processing (Hummel & Nordin, 2005; Krusemark, Novak, & Gitelman, 2013). The primary olfactory system activates the limbic system and includes the amygdala and piriform cortex, whereas the secondary olfactory system involves the orbitofrontal cortex (OFC), insula, hippocampus and thalamus (Hummel & Nordin, 2005). Put simply, it is suggested that sensory olfactory processing such as the detection of odors is processed at the

primary olfactory level (Pollatos et al., 2007; Krusemark et al., 2013), whereas making judgments regarding the valence of those odors requires more cognitively demanding higher order olfactory processing, thus activates regions of the brain associated with the secondary olfactory system such as the OFC and insula (Krusemark et al., 2013; Pollatos et al., 2007). Taking together the evidence that shows odor detection activates brain structures in the primary system such as the amygdala and piriform cortex (Hummel & Nordin, 2005) coupled with findings that show odors influence emotional state that in turn influence odor perception (e.g., Chen & Haviland-Jones, 2000; Pollatos et al., 2007, Porcherot et al., 2010) provide evidence to support a primary olfactory system. Given that the same neural structures involved in primary olfactory processing are also involved in emotional processing—namely the limbic system—it is not surprising that research has found robust evidence to support contention that olfaction and emotions are undeniably linked.

Olfaction and Attachment: Olfactory Comfort and Attachment Objects

Olfaction has been implicated as a key feature in social relations as it provides cues and information about others (Croy, Bojanowski, & Hummel, 2013; de Groot et al., 2012). There is substantial evidence that shows that the olfactory system facilitates olfactory identification and recognition of loved ones and familiar significant others (Mallet & Schaal, 1998), attraction (Thornhill, & Gangestad, 1999), and mate-selection (Herz & Inzlicht, 2002). However, to date, no study has directly investigated olfactory ability and attachment. The little work that exists on olfaction and relationships is focused on linking odors with maternal behavior (e.g., Badiee et al., 2013; Varendi et al., 1994), or mate selection (e.g., Herz & Inzlicht, 2002; Wedekind et al., 1995). To our knowledge, only two studies have specifically investigated attachment and olfaction. McBurney et al. (2006) and Shoup et al. (2008) investigated olfactory comfort which is the practice of smelling a romantic partners' or loved ones' clothing during periods of separation in order to feel closer comforted, closer to them and to reduce distress experienced during periods of separation. However, both these studies

were still within the context of odors rather than investigating the role of olfaction in these outcomes. Moreover, they regarded attachment as a term signifying a relationship bond rather than directly investigating the practice of olfactory comfort in terms of individuals attachment styles. Therefore, there remains no existing literature on the link between olfaction and attachment styles.

Research Aims

The paucity of research on the link between olfaction and human attachment is surprising. The mounting evidence investigating olfaction and social communication, social relations and emotions indicates that olfaction plays a crucial role in the bonding process (e.g., between mother and infant) are equally important in adult relationships (e.g., attraction, relationship behavior). Yet, to date, there is no research that has investigated functional olfactory ability in human attachment.

The link between olfaction and attachment is evidenced by the fact that they share several structural parts of the brain that include neural processing for relationship and emotional processing. Given there is a relationship between olfaction and emotions (due to overlapping neural structures), and both olfaction and emotions have been implicated as playing a crucial part in the facilitation of social relationships (such as communication, interaction and bonding), then it stands to reason there would be a relationship between olfactory ability and attachment style. It is readily agreed that human infants are born with a highly functioning olfactory ability in order to facilitate attachment and bonding during infancy. Taking this view further, we theorize that olfactory ability could therefore either facilitate or impede the attachment process. Our working hypothesis is that this premise can be extended to adult attachment styles; whereby individuals with greater relationship outcomes or want greater relationships would demonstrate better olfactory ability. In other words, better olfactory ability would be linked to a more secure type of attachment. Therefore, the aim of the present study is to investigate the relationship between olfactory ability and adult

attachment style, and if this olfactory ability differs across the attachment styles. Given the links previously known between olfaction, emotions and wellbeing, the present study will also investigate empathy (via an empathy questionnaire), psychological wellbeing (with the Depression, Anxiety and Stress Scale–DASS) and individuals' attitudes to smell (via a questionnaire that measures the importance of olfaction in everyday life). As this is the first study to investigate these olfactory ability and adult attachment, hypotheses will be based on previous knowledge and theories on attachment styles and olfactory functions in order to make predictions.

Hypotheses

Hypothesis 1: Relationship between Adult Attachment Style and Olfactory Ability.

We hypothesize there should be a relationship between olfactory ability and attachment styles. Specifically, it is predicted that individuals who self-report higher secure or preoccupied attachment should demonstrate better olfactory ability, whereas individuals who self-report higher fearful or dismissing attachment should demonstrate poorer olfactory ability.

Hypothesis 2: Differences in Olfactory Ability between Adult Attachment styles.

We hypothesize there should be differences in olfactory abilities between the attachment styles. Specifically, individuals who describe themselves as secure, preoccupied or fearful should demonstrate better olfactory ability compared to those who describe themselves as dismissing. In turn, those who describe themselves as dismissing should demonstrate poorer olfactory ability compared to those who describe themselves as secure, preoccupied or fearful.

Hypothesis 3: Relationship between Attachment Style and Importance of Olfaction in Everyday Life.

We hypothesize there should be a relationship between adult attachment and how individuals evaluate the importance of olfaction. It is predicted that secure, preoccupied and fearful individuals will evaluate the importance of olfaction higher than dismissing individuals.

Hypothesis 4: Relationship between Adult Attachment Style, Empathy and DASS scores.

We hypothesize there should be a relationship between adult attachment and empathy and with each subscale of the DASS. It is predicted that more securely attached individuals should self-report higher empathy and lower scores on each of the DASS subscales. Individuals higher on preoccupied attachment should similarly be associated with higher empathy but greater scores on each of the DASS subscales. Individuals higher on fearful attachment should be negatively associated with empathy and positively associated with each of the DASS subscales. Individuals who describe themselves as dismissing should be negatively associated with empathy and report lower scores on each of the DASS subscale. For a visual representation of these interactions see Figure 2.

	High Empathy	Low Empathy
High DASS	Preoccupied	Fearful
Low DASS	Secure	Dismissing

Figure 2. Cross-table of predicted interaction associations between Attachment Style, with Empathy and DASS scores

Methods

2.1 Participants

Eighty (61 female, 77%; 19 male, 23%) first-year psychology undergraduates from Macquarie University, aged 17 to 42 years ($M=19.99$, $SD = 4.09$) participated in the present 2-part study for course credit. Participants were recruited via the Macquarie University online participant pool (SONA) and advised they were to complete a series of online questionnaire prior to their laboratory session on campus (see Appendix A). On the day of the in-lab session, all participants indicated they were in current good health with none report any olfactory disturbances (such as hay-fever or flu), or histories of major head injuries. Participation was voluntary with informed consent being obtained prior to completing the online questionnaires and prior to the commencement of the laboratory session. (see Appendix B & C)

Ethical approval for this study was obtained from the Macquarie University Human Research Ethics Committee (HREC; Human Sciences and Humanities; reference number: 5201600167), thereby meeting the requirements set out in the *National Statement on Ethical Conduct in Human Research* (2007). Data collection was treated in accordance with the university's ethical guidelines for data protection.

2.2 Measures & Materials

Self-report Measures

The Relationship Questionnaire (RQ; Bartholomew & Horowitz, 1991). The RQ is a measure of individual differences designed to categorize adults into one of the four attachment styles outlined by Hazan and Shaver's (1987) Adult Attachment theory. Participants were presented with the four short paragraphs that described the different attachment styles: Secure, fearful, preoccupied, and dismissing (see Appendix D) and asked to select only one paragraph that best described their general close relationship style. Based on their selection, participants were classified as falling into that categorical attachment style.

The Relationship Scales Questionnaire (RSQ; Bartholomew & Horowitz, 1991).

The RSQ is an extended version of the RQ designed to measure the four attachment styles on a dimensional scale. The RSQ divides the paragraphs of the RQ into 18 questions or statements that target the four attachment styles (see Appendix E). Example items from each category are: Secure (“I find it easy to get emotionally close to others”); Fearful (“I find it difficult to trust others completely”), Preoccupied (“I find that others are reluctant to get as close as I would like”); and Dismissing (“I am comfortable without close emotional relationships”). Participants were asked to rate their level of agreement to the statements with regard to their ‘general close relationship style’. Ratings were on a 9-point Likert scale ranging from 1 (*not at all like me*) to 9 (*very much like me*). After reverse scoring items 6, 9, and 28, items relevant to each category were averaged to obtain final scores for each for each participant. Potential scores for Secure and Dismissing attachment ranged from 5 to 45; potential scores for Preoccupied and Fearful attachment ranged from 4 to 36. Higher scores indicated higher orientation with that particular attachment style. The current study demonstrated overall strong internal consistency ($\alpha = .82$) using this measure.

Questionnaire Measure of Emotional Empathy (QMEE; Mehrabian & Epstein, 1972) is a 33-item measure of emotional empathy (a vicarious emotional response to the perceived emotional experiences of others). Participants rated their agreement on a 9-point Likert scale from 1 (*disagree very strongly*) to 9 (*agree very strongly*) to statements such as “Seeing people cry upsets me” (see Appendix F). QMEE total score was calculated by summing all items, after reversing 16 items (2, 3, 4, 6, 11, 13, 15, 20, 21, 22, 23, 24, 26, 28, 30, 32, 33). Potential scores ranged from 33 to 297 with higher scores indicating a stronger empathic tendency towards others’ emotional states. The current study demonstrated overall appropriate internal consistency ($\alpha = .61$) using this measure.

Depression, Anxiety and Stress Scale–Short Form (DASS-21; Lovibond, 1995). The DASS-21 is a short version of the full DASS-42; a measure used for assessing individuals’

experiences on three subscales: Depression, anxiety and stress. The DASS is suitable for screening non-clinical adolescents and adult populations (see Appendix G). Each of the three DASS subscale consists of 7 items that assess depression (e.g., “I don’t seem to experience any positive feeling at all”), anxiety (e.g., “I worry about situations in which I might panic and make a fool of myself”), and stress (e.g., “I find it hard to wind down”). The statements were reframed to the present tense and participants were asked to rate the extent that each statement applies to them ‘in general’. Participants rated agreement on a 4-point Likert scale with no neutral option, ranging from 1 (*does not apply to me at all*) to 4 (*applies to me very much or most of the time*). Final scores for each subscale were summed and, per authors instructions, scores were then multiplied by 2 so the scores were comparable with the full-form DASS normative scores. Potential scores for each subscale ranged from 7 to 56 with higher scores indicate greater levels of depression and/or anxiety and/or stress. The current study demonstrated very good internal consistency for Depression ($\alpha = .85$), Anxiety ($\alpha = .77$) and Stress ($\alpha = .83$) using this measure.

The Importance of Olfaction Questionnaire (IOQ; Croy et al, 2010). The importance of olfaction questionnaire (IOQ) is an 18-item self-report questionnaire designed to assess the value that participants’ place on their sense of smell (see Appendix H). The questionnaire has been shown to be suitable for normosmic subjects (having normal olfactory functioning), and patients with hyposmia (reduced olfactory ability) or anosmia (no olfactory functioning). Participants rated their agreement on a 4-point Likert scale ranging from 1 (*I totally disagree*) to 4 (*I totally agree*). The scale is designed to measure the significance that individuals place on smell across three primary categories: *Association* which refers to emotions, memories, and values evoked by the sense of smell (e.g., “Certain smells immediately activate strong feelings”); *Application* that reflects the extent individuals employ smell in their daily lives (e.g., “I smell foods to find out whether it is spoiled or not”); and *Consequence* that represents the extent that individuals rely on their olfactory sense in daily decision making (e.g., “If my

partner has a nasty smell, I try to avoid kissing him/her”). A total score was computed for each participant by summing all items, with potential scores ranging from 16 to 64. For this study we computed a total score by summing all 16 items of the IOQ to assess general attitudes toward the sense of smell. The current study demonstrated overall strong internal consistency ($\alpha = .83$) using this measure.

Olfactory Test

The Sniffin’ Sticks (Hummel, Sekinger, Wolf, Pauli & Kobal, 1997). Olfactory function was assessed using the Sniffin’ Sticks test battery (Burghart GmbH, Wedel, Germany). The Sniffin’ Sticks (Hummel et al., 1997) is a standardized re-useable and portable test-kit of nasal chemosensory (olfactory) function comprising three distinct subtests of olfactory functioning: Odor threshold, odor discrimination (non-verbal approach) and odor identification (verbal approach). The Sniffin’ Sticks kit contains 112 individual felt-tip pens each containing 4mL of a liquid odorant or odor dissolved in propylene glycol. The pens are individually capped to prevent odor contamination. For odor presentation, the experimenter—wearing cotton gloves to avoid odor contamination—removes the cap and presents each pen to the participant by holding it approximately 2cm beneath both nostrils for approximately 3-5 seconds. For tests where the participant is blindfolded (i.e., odor threshold and discrimination tests) presentation is accompanied by a verbal command (e.g., “number 1”, “number 2”, etc) to indicate to the participant that it is time to sniff. The blindfold is necessary to prevent visual identification that may come from the pen presentations.

Odor Threshold. The odor threshold subtest is a measure of general olfactory sensitivity using a triple-forced choice paradigm and *n*-PEA as the odorant. The test contains 16 levels of varying *n*-PEA concentrations 1 (*strongest odor concentration*) to 16 (*weakest odor concentration*). Each of the 16 levels comprises a triplet of pens; one target pen containing the odorant at a particular dilution and two solvent (odorless) distracter pens. The participant was familiarized with the *n*-PEA odor at the strongest concentration prior to the

commencement of the test. Pens were then randomly presented in a singular sequence to the blindfolded participant. The task of the participant was to correctly determine which of the three pens contained the odorant. The task followed the single staircase method outlined by Doty et al. (1991) and Hummel et al. (1997). For time efficiency, we started with trial number 10 as the lowest concentration and participants were exposed to progressively higher concentrations of *n*-PEA until the target odor pen was correctly identified in two successive trials. Correct identification then triggered a reversal of the staircase (from higher to lower concentrations) until the participant made a single error triggering another reversal (from lower to higher concentrations) and so forth until seven reversals were completed. Participants' detection threshold scores was the mean of the last four reversal levels in the staircase. Possible scores ranged from 1 to 16 with higher scores indicating greater odor sensitivity thereby better olfactory ability).

Odor Discrimination. The Odor Discrimination subtest assesses a participant's ability to discriminate between two odours using a forced-choice paradigm. The test involves 16 trials with each trial consisting of a triplet of pens; two pens containing the same odorant and one pen containing a different odorant. Participant were asked to determine which of the three pens contained the different odor (i.e., smelled differently). Each pen was presented singularly in sequence to the blindfolded participant, with a 10-second interval between pen presentations and a 30-second interval between trials. The order of pen presentation in each trial was counterbalanced per the instructions in the Sniffin' Sticks manual. One point was allocated for every correct response. Potential odor discrimination scores ranged from 0 to 16, with higher scores indicating a greater ability to discriminate between odors and thereby better olfactory ability.

Odor Identification. The Odor Identification subtest measures a participants' ability to identify common odors (such as banana, cinnamon, coffee, etc) in a four-forced-choice paradigm. The test consists of 16 individual odor pens each containing a different odor. The

task of the participant was to identify the odor (they smelled) from the corresponding flash card that contained four alternative choices; the correct response and three distracters. Odor pens were presented to participants one at a time in sequential numerical order (1 to 16). One point was given for every correct response. Possible odor identification scores ranged from 0 to 16, with higher scores indicating a greater odor identification and thereby better olfactory ability.

To calculate total olfactory ability all scores for the three olfactory tests (threshold, discrimination, and identification) were summed to obtain a total TDI score. TDI scores ranged from 3 to 48 with higher TDI scores indicating better general olfactory ability.

2.3. Procedure

The present study was conducted in two parts, totaling 60 minutes. Part one was completed online prior to part two. Part two of the experiment was completed in the laboratory on campus. This two-part process was done to facilitate efficient administration of the study.

In part one, participants were emailed the link to the online questionnaire battery after sign-up and asked to complete the questionnaires prior to coming to the laboratory session. In the online questionnaires (hosted by Qualtrics surveys), they were asked to answer basic demographic questions as well as questions relating to their current relationship status, perceived olfactory ability and general health status. They also completed the following scales: RQ, RSQ, DASS-21, QMEE and IOQ. Questionnaires were presented in random order.

In part two, participants came to the laboratory to complete olfactory testing with the experimenter. Data collection was conducted in a well ventilated/sterile room (i.e., closed windows with cyclonic air) in the Food and Smell laboratory at Macquarie University and took approximately 30-40 minutes. First, demographic information was obtained and a brief Health and Head Injury Interview (see Appendix I) was conducted by the experimenter which

included questions relating to participants' past and present health history (e.g., "Have you ever had nasal or facial surgery?"). The purpose of this interview was to screen for potential confounding factors such as head injuries, nasal issues or surgeries that may compromise olfactory performance. Each participant completed the odor subtests in the following order: Odor threshold, odor discrimination, and odor identification. A 5-minute break was allowed between each subtest to prevent olfactory fatigue and adaptation. At the conclusion of the test participants were thanked for their participation and appropriate course credit was awarded.

Results

3.1. General Statistical Approach

The results section is comprised of preliminary and main analyses. All analyses were conducted using SPSS (version 22). Preliminary analyses were conducted that included tests of normality and assumptions as well as obtaining frequencies and descriptive information for the variables used in the main analyses. Next, the main analyses were conducted to obtain results for the primary research questions: (1) is there a relationship between adult attachment style and olfactory ability?; (2) do different adult attachment styles demonstrate different olfactory ability?; (3) is there a relationship between adult attachment styles and olfactory importance?; and, (4) is there a relationship between adult attachment styles with empathy and DASS scores. Statistical analyses were performed using Pearson product-moment correlations (Correlations) and one-way Analysis of Variance (ANOVA).

3.2. Preliminary Analyses

Normality: Normality was measured by assessing the standardized skewness and kurtosis statistic for each variable. In accordance with recommendations by McQueen and Knussen (2006), a number ranging between +1.96 and -1.96 was used to determine normality. All variables, with the exception of age, were normally distributed. Given the sample population was primarily undergraduates, a strong positive leptokurtic skew was not surprising.

Descriptives: Eighty participants comprised the final sample. For descriptives, see Table 1.

Table 1

Descriptive for the variables of interest for the total sample and by attachment style

	Total Sample <i>M</i> (<i>SD</i>) (<i>N</i> = 80)	Secure <i>M</i> (<i>SD</i>) (<i>N</i> = 33)	Fearful <i>M</i> (<i>SD</i>) (<i>N</i> = 16)	Preoccupied <i>M</i> (<i>SD</i>) (<i>N</i> = 13)	Dismissing <i>M</i> (<i>SD</i>) (<i>N</i> = 18)
Gender					
- female	(<i>n</i> = 61)	(<i>n</i> = 25)	(<i>n</i> = 1)	(<i>n</i> = 4)	(<i>n</i> = 6)
- male	(<i>n</i> = 19)	(<i>n</i> = 8)	(<i>n</i> = 15)	(<i>n</i> = 9)	(<i>n</i> = 12)
TDI score	30.35 (4.83)	30.19 (4.40)	33.55 (3.95)	28.63 (5.64)	29.07 (4.71)
Empathy	194.02 (21.16)	17.64 (5.33)	208.75 (24.67)	22.92 (7.69)	21.44 (9.94)
DASS-D	20.43 (7.55)	23.45 (7.42)	23.00 (7.08)	29.95 (10.08)	24.33 (5.75)
DASS-A	25.65 (7.95)	24.85 (6.50)	28.25 (7.44)	31.85 (7.50)	29.11 (11.77)
DASS-S	28.65 (8.72)	195.61 (16.65)	33.38 (6.64)	196.54 (14.56)	176.22 (17.96)

Note. Table presenting means and standard deviations for the total sample and by attachment style for the main variables of interest. DASS-D = Depression, DASS-A = Anxiety, DASS-S = Stress.

^aThe percentage of adults in each attachment category approximates those of infants in Hazan and Shaver (1987).

3.3. Main Analyses

H1. Relationship between attachment style and olfactory ability?

Pearson product-moment correlations were obtained to investigate if there was a relationship between TDI score and attachment styles (secure, preoccupied, fearful and dismissing). Correlational tests for the four priori hypotheses were Bonferroni adjusted to alpha levels of .0125 (.05/4) per test. Alpha's for the intercorrelations remained set at 0.05.

Correlations revealed the relationships between attachment styles and TDI score were not statistically significant. A summary correlation matrix is displayed in Table 2. Notably, although the relationships were not significant and weak, secure attachment and TDI score was

negatively associated with TDI score, while fearful attachment was positively associated with TDI score. These findings are inconsistent with predictions. Intercorrelations between the subgroups of the variables, with the exception of the relationship between secure and dismissing attachment, were significant.

Table 2

Correlations Among and Between Attachment styles and with TDI scores (N=80)

Measure	1. Secure	2. Preoccupied	3. Fearful	4. Dismissing.	5. TDI
1. Secure	—	-.240*	.474***	-.097	-.134
2. Preoccupied	-.240*	—	-.271*	.247*	.169
3. Fearful	.474***	-.271*	—	.271*	.086
4. Dismissing	-.097	.247*	-.258*	—	-.021
5. TDI	-.134	.169	.086	-.021	—

Note. * $p < .05$; ** $p < .0125$; *** $p < .001$. Alphas for correlations between variables were set at .004 to control for type I errors. TDI = Total olfactory ability comprising Threshold, Discrimination and Identification composite test scores

H2. Differences in olfactory ability according to attachment style?

A one-way between subjects ANOVA was conducted to investigate differences in TDI score (DV) and attachment factor (secure, preoccupied, fearful and dismissing). Levene's statistic test of homogeneity was not significant ($p = .686$) therefore the test did not violate any assumptions. Tukey post-hoc tests were used, with alpha being set at .05 (two-tailed), to control for the type I error rate.

Statistical analyses revealed a significant main effect of TDI score and at the .05 level, $F(3, 76) = 3.64$, $p = .016$. Post hoc analyses using the Tukey post hoc criterion for significance indicated that the average TDI score for individuals with fearful attachment was significant greater ($M = 33.55$, $SD = 3.95$) than individuals with a preoccupied attachment style ($M = 28.63$, $SD = 5.64$), $F(1, 76) = 4.91$, $p = .033$, and dismissing attachment style ($M = 29.07$, $SD = 4.71$) $F(1, 76) = 4.48$, $p = .036$. These results indicated that fearful individual had significantly better olfactory ability than preoccupied and dismissing individuals (see

Figure 3). This finding was consistent with predictions that fearful individuals would demonstrate better olfactory ability than dismissing individuals.

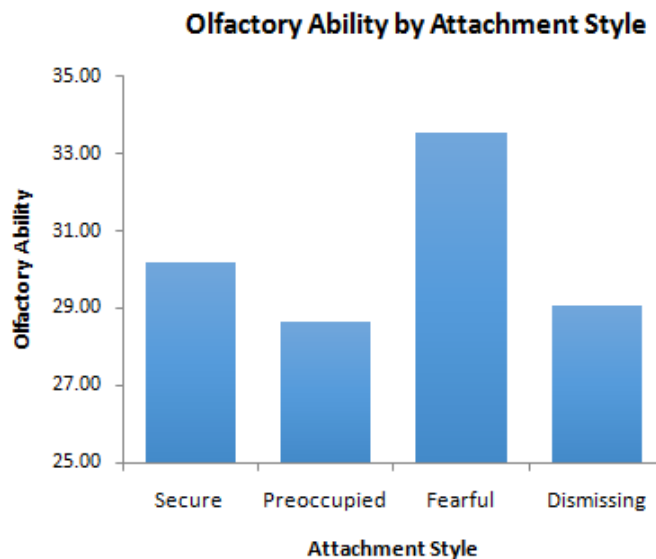


Figure 3. Bar graph showing the relationship between each Attachment Style and TDI score

H3. Relationship between attachment styles and the importance of olfaction scale (IOQ)

A correlation analysis was conducted to investigate relationships between attachment and IOQ score. Tests for the four priori hypotheses were Bonferroni adjusted to alpha levels of .0125 (.05/4) per test. Intercorrelations were not evaluated in this analyses as they investigated in an earlier analysis. A summary correlation matrix is displayed in Table 3 (intercorrelations are also reported as a reference).

Results showed that individuals higher on fearful and preoccupied dimensional attachment were associated with significantly higher IOQ score. Results also showed the individuals higher on secure attachment was significantly associated with lower IOQ score. The positive relationship between higher preoccupied individuals and IOQ score was consistent with predictions. However, the positive relationship between fearful attachment and IOQ, and the negative relationship between secure attachment and IOQ were inconsistent with predictions.

Table 3

Correlations Between (and Among) Attachment styles and with IOQ scores (N=80)

Measure	1. Secure	2. Preoccupied	3. Fearful	4. Dismissing.	5. IOQ
1. Secure	–	-.240*	.474***	-.097	-.270*
2. Preoccupied	-.240*	–	-.271*	.247*	.376***
3. Fearful	.474***	-.271*	–	.271*	.413***
4. Dismissing	-.097	.247*	-.258*	–	.108
5. TDI	-.134	.169	.086	-.021	–

Note. * $p < .05$; ** $p < .0125$; *** $p < .001$. Alphas for correlations between variables were set at .004 to control for type I errors. IOQ = Importance of Olfaction Questionnaire score.

H4. Relationship between attachment styles, empathy and DASS scores

Correlation analysis was conducted to investigate relationships between attachment and empathy, and attachment and each subtest of the DASS. Tests for the 16 priori hypotheses were Bonferroni adjusted to alpha levels of .003 (.05/16) per test. A summary correlation matrix is displayed in Table 4. A positive relationship was observed between individuals higher on preoccupied and fearful attachment and empathy. However, this was not significant after Bonferroni adjustment to alpha .003. No significant relationship, nor either positive or negative direction, was observed between secure attachment and empathy. A significant negative relationship was observed between individuals higher on secure attachment and depression and stress but not anxiety. A significant positive correlation was observed between individuals higher on preoccupied attachment and anxiety but not depression or stress. Individuals higher on fearful attachment showed significantly higher levels of depression. Fearful individuals also showed higher levels of anxiety and stress but these relationships were not significant after Bonferroni adjustment to alpha .003. These relationships partially supported our hypotheses. As predicted, no significant relationships were observed between dismissing attachment and any of the DASS subtests.

Table 4

Correlations between Attachment, Empathy and each subtest of the DASS (N=80)

Measure	Empathy	Depression	Anxiety	Stress
Secure	.000	-.441***	-.213	-.391***
Preoccupied	.225*	.130	.389***	.215
Fearful	.276*	.377***	.274*	.225*
Dismissing	-.192	.069	-.039	.141

Note. * $p < .05$; ** $p < .003$; *** $p < .001$. Alphas were set at .003 to control for type I errors

Depression, Anxiety, Stress = DASS

Discussion

In the present study we aimed to extend the growing body of literature by investigation olfaction in socio-relational functions. Specifically, we investigate olfactory ability and adult attachment style. We investigated individuals' evaluation of olfaction in their everyday lives, their levels empathy and psychological health (i.e., DASS). To our knowledge this is the first study to investigate olfactory function in the context of attachment style thus the findings should be considered preliminary and exploratory in nature.

Summary of Present Findings

We predicted that highly secure and preoccupied individuals would demonstrate better olfactory ability than those low on secure and preoccupied attachment, and that individuals higher on fearful and dismissing dimensional attachment would demonstrate poorer olfactory ability than those low on fearful and dismissing attachment. Correlations indicated that there were no significant relationships between olfactory ability and dimensional attachment styles. However, ANOVA analysis revealed differences in olfactory scores between attachment groups. Specifically, we found that individuals who described themselves as having a fearful attachment style demonstrated significantly better olfactory ability than individuals who described themselves as preoccupied or dismissing. These findings are inconsistent with prediction thus did not support our hypotheses.

It was also expected that individuals higher on secure and preoccupied attachment would value olfaction as highly important whereas individuals higher on fearful and dismissing style would rate the importance of olfaction lower. Results indicated that individuals higher on preoccupied and fearful attachment evaluated the importance of olfaction in their daily lives significantly higher than those low on those dimensions. Therefore our hypotheses were partially supported.

Finally, it was predicted that attachment styles would be associated with empathy, and the subscales of the DASS (depression, anxiety, and stress). Specifically, individuals higher on secure attachment would score higher on empathy but lower on the DASS subscales, preoccupied attachment would score higher on empathy but lower on the DASS subscales, individuals higher on fearful attachment would score lower on empathy and higher on the DASS subscales, and, finally, individuals higher on dismissing attachment would score lower on empathy and DASS subscales. Present findings partially support these predictions. The relationships between empathy and attachment styles were not significant. As expected, individuals higher on secure attachment reported significantly lower levels of depression and anxiety but, unexpectedly, not stress. Individuals higher on preoccupied attachment, as expected, reported higher levels of anxiety but, unexpectedly, not depression or stress. As expected, individuals higher on fearful attachment reported higher levels of depression but positive relationships with anxiety and stress were not significant after Bonferroni adjustment for multiple tests. No significant relationships were observed between dismissing attachment style, empathy or DASS scores.

Interpretation of Present Findings

Based on the existing body of previous literature that has evidence robust links between olfaction, emotions and relationships, we hypothesized there would be an association between olfactory ability and adult attachment style. However, present findings – with the exception of the finding that fearfully attached individuals demonstrated better olfactory

ability – did not support our predictions. Although no previous studies have specifically investigated olfaction and attachment styles (in either infants or adults), the present results are nonetheless surprising, and inconsistent with other research that has demonstrated significant associations between olfaction, psychological health, emotions and relationship types (e.g., Badiee et al., 2013; Chalouhi, 2005; Croy, Nordin et al., 2014; Croy, Symmank, et al., 2014; Deems et al., 1991; de Groot et al., 2012; Herz & Inzlicht, 2002, McBurney et al., 1976; McBurney et al., 2006; Sbarra, 2006; Shoup et al., 2008; Silvia, 2008, Mallet & Schaal, 1998; Porter, R. H., & Moore, 1981; Porter, 1992; Porter & Moore, 1981; Russell et al, 1983; Varendi et al., 1994).

The Link Between Olfaction and Depression

The results of the present findings indicated that individuals with a fearful attachment style had better olfactory ability but that they also had higher levels of depression. This suggests that depression may a contributing factor to the observed relationship between fearful attachment style and greater olfactory ability. However, this seems to be inconsistent with previous animal and human studies (e.g., Croy, Symmank et al., 2014; Negoias et al., 2010) that have showed strong links between reduced olfactory performance and depression. For example, in a study investigating olfactory function and depression, Croy, Symmank et al. (2014) consistently found reduced olfactory processing in depressed women before psychotherapy, but found no difference in olfactory functioning between the depressed patients and healthy controls after psychotherapy. From this they concluded that olfaction was an indicator of depression. In a similar study, Negoias et al. (2010) found patients with acute major depressive disorder showed significantly lower olfactory sensitivity. Furthermore, they found reduced olfactory bulb volume in depressed patients thus proposing that the relationship between depression and olfaction may be reciprocal (Negoias et al., 2010).

In contrast to previous research, present findings indicate an opposite relationship, namely that depression is associated with increased olfactory functioning. One possible

reason for this inconsistent finding may be due to the proposed two-level processing system of olfactory functioning. Olfaction researchers maintain that the olfactory system is comprised of a primary (sensory) level, for processing environmental odors and a secondary level that is responsible for higher order olfactory functioning (Krusemark et al., 2013; Negoias et al., 2010; Pollatos et al., 2007). They have further suggested that threshold tests (such as the one in the Sniffin Sticks test kit) assess olfactory sensitivity at the primary level, and discrimination and identification tests assess olfactory functioning at the secondary level (Negoias et al., 2010; Pollatos et al., 2007). The present study utilized a total olfactory score that combined the scores from the three individuals Sniffin Sticks tests.

Some researchers have proposed that poorer olfactory functioning observed in depressed persons is associated with the primary but not the secondary level of olfaction (e.g., Croy, Symmank et al., 2014; Krusemark et al., 2013; Pollatos et al., 2007; Lombion-Pouthier et al., 2006; Pause, Miranda, Göder, Aldenhoff, & Ferstl, 2001). For example, Negoias et al. (2010) reported reduced olfactory perception and sensitivity in depressed persons. Olfactory sensitivity is measured by threshold tests to assess functioning in the primary (sensory) level of olfaction. The finding has been replicated in other studies where it was found depressed patients exhibited primary olfactory processing as evidence by poorer olfactory sensitivity (e.g., Lombion-Pouthier et al., 2006; Pause et al., 2001). Taken together, these findings suggest that the link between depression and poorer olfactory functioning may be confined to the primary olfactory system.

However, the above does not explain why we observed greater olfactory performance in fearful attachment individuals with higher levels of depression. Although it is possible that fearful individuals did perform poorly on threshold tests but equally performed very well on the discrimination and identification tasks therefore the combined scores concealed olfactory deficits in primary level threshold sensitivity. Furthermore, if indeed depression was a mediating factor then we would observe a similar pattern but in the opposite direction. For

instance, individuals with greater levels depression should demonstrate poorer olfactory ability and vice versa. However, this theory was not the case in the present study. High securely attached individuals scored significantly lower on depression, as expected, but also demonstrated poorer ability on the olfactory tests compared with fearfully attached individuals who performed better in the olfactory tasks and scored higher on depression. This suggests that depression may not be a direct determinant of olfactory functioning.

Olfaction Perception and Emotional States

It is widely accepted that odors can affect and induce emotions (Pollatos et al., 2007). This is not surprising given that olfactory pathways are predominantly limbic afferents. According to previous research, olfactory perception, in turn, is equally influenced by the perceiver's emotional state. In fact, Krusemark et al., (2013), suggest that olfactory perception is dominated by emotions. For example, Pollatos et al., (2007) found participants who were induced to a negative state judged odor as more intense than those in a neutral state. Moreover, after negative-state induction olfactory threshold sensitivity was significantly reduced for males and females, whereas inducing an odor discrimination performance was not affected by emotional state. The authors theorized that the reduction in threshold performance was evidence that emotional states interfere with olfactory processing at the primary level. Moreover, evidence suggests that brain structures of the primary olfactory system (i.e., piriform cortex and amygdale) were active when perceiving odor intensity which provided further evidence that the connection between odors and emotions is processed at the primary level (Krusemark et al., 2013; Pollatos et al., 2007). Krusemark et al. (2013) found induced anxiety similarly affected olfactory sensitivity by reducing odor detection speed. Moreover, after anxiety-induction, anxiety-induced participants' demonstrated altered affective perception and previously neutral odors became more negatively-valenced (Krusemark et al., 2013; Pollatos). These findings suggest that negative emotions, and in particular, anxiety may impede olfactory ability and may explain why preoccupied individuals

in the present study demonstrated poor olfactory ability given the concurrent high levels of anxiety.

Interestingly, both fearful and preoccupied attachment styles evaluated olfaction as highly important in their daily lives. Nevertheless, results revealed that individuals with a fearful attachment style had better olfactory ability than preoccupied individuals. This finding potentially supports the view that higher levels of anxiety may be impeding olfactory functioning, especially at the primary level. Both attachment styles reported analogous perceptual attitudes to smell but the attachment style with the lower level of anxiety performed better than the attachment style with higher level anxiety.

Limitations and Directions for Future Research

The present study also has limitation that should be noted and considered for future research. We defined olfactory ability as the combined sum of the scores for the three odor tests (threshold, discrimination, and identification). However, the olfactory system can be differentiated into primary and secondary levels of processing (e.g., Croy, Symmank et al., 2014; Krusemark et al., 2013; Pause et al., 2001; Pollatos et al., 2007). The primary olfactory system is involved with peripheral sensory processing while the secondary olfactory system is typically concerned with higher order cognitive processing (Krusemark et al., 2013). Given the different levels of olfactory processing, some researchers suggest olfactory tests (e.g., Sniffin Sticks) should be examined according to peripheral processing – via the primary system (e.g., threshold test), and those measuring higher order cognitive processing–via the secondary olfactory system (e.g., discrimination and identification tests). The present study used a combined measure of olfactory ability as suggested by Negoias et al., (2010) for the following reasons.

First, the primary olfactory system shares neuroanatomy with the primary emotion system (e.g., amygdala). Research has shown emotional states such as negative affect and anxiety reduced olfactory perception (e.g., Krusemark et al., 2013; Pollatos et al., 2007) thus

could interfere with threshold performance. Second, the secondary olfactory system (assessed by odor discrimination and identification tests) recruits cognitive processes such as memory and knowledge (Krusenmark et al., 2013). As such it is probably that this level of processing is linked to several neurological and neuropsychological disorders (Croy, Symmnak et al., 2014). However, findings investigating olfactory function in depression persons have revealed conflicting results. While some studies find evidence that olfactory functioning is affected at the primary (emotional) processing level (Negoias et al., 2010), others have found depressed persons performed poorer on discrimination and identification tasks indicating association with the secondary (cognitive) level of olfactory functioning (e.g., Croy, Symmnak et al., 2014). Certainly, independent testing of olfactory ability according to tests assessing primary and secondary processing could provide further information about the relationship between olfaction and attachment. However, given these inconsistent findings coupled with the fact that this was a preliminary investigation of olfactory ability, a total olfactory score was sufficient to examine unexplored relationships between these two variables. However, further research should explore the different levels of olfactory processing, especially given their differential functions.

A second limitation consideration is the self-categorization qualities of attachment measures. The existence of adult attachment styles is evidenced by an extensive body of literature suggesting that the theory of adult attachment styles is robust. Consequently, it is generally assumed that attachment styles are relatively stable, not only across the lifespan, but across relationships. However, recent research is seeing a change in attachment styles, in particular, how individuals identify with them (Konrath, Chopik, Hsing, & O'Brien, 2014). A recent meta-analysis of 94 samples of American college students discovered that the percent of students with secure attachment style has decreased in recent years, while the percent of students with insecure attachment styles (e.g., preoccupied, fearful and dismissing) had increased across the same time period (Konrath et al., 2014). In other words, a larger number

of students described themselves as having a dismissing attachment style (i.e., comfortable without close emotional relationships) compared with college students in the late 1980s (Konrath et al., 2014). According to Konrath et al. (2014) the recent increases in independent, entitlement and narcissism coupled with simultaneous decreases in empathy may explain this shift in attachment styles. Perhaps this changing attitude towards independence is why none of the attachment styles were associated with empathy in the present study. Going forward, researchers need to factor social changes when evaluating attachment styles and subsequent associations.

A further consideration for assessing attachment styles is, if adult attachments are sensitive to the social environment and relationships – as indeed they should be – it logically follows that attachment may be a fluid and reciprocal; altering and adapting varied social situations and relationship. For example, a predisposed fearful individual may be attached to a secure partner who is loving and supportive and has proven deserving, subsequently drawing out a similar attachment response. On the other hand, if an individual may find themselves in a relationship (e.g., romantic, social or professional) with a harsh, dismissing type, that may elicit a preoccupied attachment response from an otherwise secure person. Therefore, it may not longer be useful to consider adult attachment as a stable construct that developed in infancy. Perhaps a more accurate measure of attachment is, as has been suggested, by the two intersections of the underlying dimensions: *Anxious-attachment* dimension and an *avoidance-attachment*. Research has identified that attachment styles can also be re-described as: Secure attachment involves low anxiety/low avoidance; preoccupied involves high anxiety/low avoidance; fearful avoidant involves high anxiety/high avoidance; dismissive avoidant involves low anxiety/high avoidance. Re-conceptualizing attachment style as individuals more high or low on anxiety or avoidance may generate different results as this might tap into a more fluid conceptualization of attachment.

An individual may categorize themselves in the particular attachment style they wish themselves to be or see themselves to be, rather than what they truly are with regard to the four criteria categories of attachment: Proximity maintenance, safe haven, separation distress and secure base (Bowlby, 1969; Hazan & Shaver, 1987). Perhaps attachment would be better assessed by other-ratings rather than self-report. That said, one limitations of using self-report data is the potential for individuals to respond in a socially desirable way. However, research suggests the RQ is particularly robust and sensitive to social desirability biases compared to other measures of attachment (Leak & Parsons, 2001). Nevertheless, future research should examine attachment styles with other measures such as observations in experimental manipulation (e.g., adults in the Strange Situation; Ainsworth et al., 1978), as well employing physiological and neurological methodologies.

Other Mediating Psychological Factors

It is also important to consider other mediating factors that may facilitate or impede olfactory functioning but were not considered in this study. A limitation of the present study may relate to participants' use of alcohol and/or drugs. Previous research has identified that individual with drug and/or alcohol dependence have poor olfactory abilities, particularly in threshold and identification tests. Although a health and head injury interview was conducted for all participants in the present in an effort to rule out potential risk factors (e.g., head trauma, nasal infections, drug use), the interview relies on (a) participants' honesty and (b) participants awareness. It is likely some participants responded to particular questions less than honestly or simply are unawares about the implications of some behaviors which may interfere with their olfactory ability. Moreover, other, less-common, psychiatric disorders have been linked to poor olfactory functioning. For example, Lombion-Pouthier et al., (2006) found anorexic patients also showed poorer olfactory performance. Though the extent of this relationship is still unknown. Given the population in the present study – mostly young females – it is not unreasonable to consider the possibility that other psychiatric concerns may

have impacted on their olfactory performance. This area would be particularly interesting for future research to investigate, especially given that females are typically more olfactory-oriented.

Study Sample

The sample was a convenient sample the comprised, mostly female, university students. This was both strength and a limitation. First, the RQ is commonly given to college students and there are numerous studies supporting its validity in this population group (see Konrath et al., 2014 for review). Further, this is perhaps the ideal sample population to investigate relationship styles as the majority will be in comparable life stages (e.g., single or dating) eliminating several potential confounding variables that may interfere with attachment style and olfactory function in community samples (e.g., marriage, divorce, age, children). Second, it is generally accepted that females are more olfactory-orientated and value intimacy and closeness more than males (de Groot et al., 2012), thus the lack of significant findings despite the dominance of female participants in the present study makes it even more surprising that a relationship between attachment style and olfaction was not observed. However, given the changing attachment landscape and increased rise of relationship independence (e.g., larger percent of people identifying as dismissing) that has been suggested in recent studies (e.g., Konrath et al., 2014), is balancing the genders. Future research should explore olfactory ability and relationship styles in gender as well as explore the growing trend of relationship independence evidence in the current generation of young adults.

Summary and Conclusion

The present study investigated the relationship between olfactory ability and attachment. Although olfaction has been researched fairly extensively in the context of relationships (e.g., infant-caregiver bonds, kin recognition and mate choice) and emotion-social communication (e.g., emotional contagion and chemosensory signaling), this is the first

study to specifically examine olfactory ability in adult attachment styles. Although findings in the present study did not reveal a clear relationship between olfaction and attachment, a relationship between these two systems cannot be ruled out. Further research and replication is required.

In sum, there is now substantial evidence that identifies olfaction as a remarkable sense that has profound implications in socio-emotional and social communication functions that serve to facilitate social relationships and interactions. Extensive examination of the literature has found evidence that olfaction is crucial in many relationship and emotional contexts and the full scope of this remarkable sense is gradually being elucidated. However, more research in this area, and particularly with respect to attachment (i.e., ability and desire to bond, connect experience intimacy with others') is crucial. As social beings, relationships are vital to our physical and emotional wellbeing. The profound implicit and explicit dominance of olfaction in many relational and emotional contexts and outcomes, warrants further investigation into the impact of olfaction in relationship styles, not only in romantic relationships, but across a broader relationship landscape.

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APPENDICES*Appendix A***SONA Advertisement****How well do you smell? Smell, Emotions and Relationships**

This study investigates the relationship between sense of smell, emotions and close relationships.

This is a 2-part study and will take 60 minutes in total.

Part 1 is ONLINE (approx. 20 minutes). You will answer a series of questionnaires, including questions relating to your health history.

***** NOTE: YOU MUST COMPLETE THE ONLINE QUESTIONNAIRES AT LEAST 6 HOURS PRIOR TO THE LAB SESSION. You will be sent the link after sign-up so please check your student email. *****

Part 2 is in the lab ON CAMPUS (approx. 40 minutes). You will complete 3 olfactory tasks that require you to smell and rate a series of odours. You will receive 60 minutes course credit for your participation.

Please come to C3B Level 5 at your allocated time.

(note: C3B is located behind C3A and next to the library. Please enter through the fire escape door)

*Appendix B***Online Consent Form****Smell, Emotions and Relationships**

CONSENT FORM

This study investigates relationship and emotional experiences, and your sense of smell.

It is being conducted by Christine Leonards to meet the requirements for a Masters of Research (Psychology) under the supervision of Dr Mem Mahmut, Department of Psychology, Macquarie University (Phone 9850 6740, email: mem.mahmut@mq.edu.au). Professor Richard Stevenson is a co-investigator on this study.

This is a two-part study. Part 1 (approx 20mins) involves completing a series of personality and relationship questionnaires ONLINE and Part 2 (approx 40) involves completing various smell tests in our lab ON CAMPUS. You will be required to complete Part 1 before coming into the lab to do Part 2.

Any information or personal details gathered in the study will remain confidential, except as required by law. Only the investigators named above will have access to the information obtained and no individual will be identified in any publication of the results. Upon completion of the study, a summary of the results will be posted outside the Chief Investigator's office (C3B 607) and on our research team's website <http://psy.mq.edu.au/lep/>. Participants are free to withdraw from the study at any time, without consequence, and will receive your course credit.

Answering some of the questions about your relationships and psychological wellbeing may make you upset. In the unlikely event this occurs, you can receive support from Lifeline (Ph.: 13 11 14; website: <https://www.lifeline.org.au>) and Relationships Australia (Ph.: 1300 364 277; website: <http://www.nsw.relationships.com.au>) or Macquarie University wellbeing centre (Ph: 02 9850 7111; website: https://students.mq.edu.au/support/health_and_wellbeing/).

To begin Part 1, you must acknowledge you have read and understand the information above and have had any questions answered to your satisfaction. By clicking "NEXT" you agree to participate, knowing that you can withdraw at any time without consequence.

*Appendix C***Information and Consent Form****Name of Project: Relationships, Emotions, and Smell**

Department of Psychology
Faculty of Human Sciences
MACQUARIE UNIVERSITY NSW 2109
Phone: +61 (0)2 9850 6740
Fax: +61 (0)2 9850 8062
Email: mem.mahmut@mq.edu.au



Chief Investigator's Name: Mem Mahmut

Chief Investigator's Title: Doctor

You have been invited to participate in a study investigating relationship and emotional experiences, and the sense of smell which is being conducted by Christine Leonards to meet the requirements for a Masters of Research (Psychology) under the supervision of Dr Mem Mahmut, Department of Psychology, Macquarie University (Phone 9850 6740, email: mem.mahmut@mq.edu.au). Professor Richard Stevenson is a co-investigator on this study.

In this study, you will be asked to a) complete personality and relationship questionnaires, b) view some movie clips and c) complete three tests of your sense of smell that require labelling and discriminating odours. This is a two-part study. Part 1 involves completing an ONLINE survey and Part 2 involves completing various smell tests in our lab ON CAMPUS. Note that you will be required to complete Part 1 before coming into the lab to do Part 2. Part 1 will take approximately 15 minutes and Part 2 will take approximately 45 minutes so you will receive 60 minutes research participation credit in total for completing both parts.

Answering some of the questions about your romantic relationships may make you upset and in the unlikely event this occurs, you can receive support from Lifeline (Ph.: 13 11 14; website: <https://www.lifeline.org.au>) and Relationships Australia (Ph.: 1300 364 277; website: <http://www.nsw.relationships.com.au>) or Macquarie University wellbeing centre (Ph: 02 9850 7111; website: https://students.mq.edu.au/support/health_and_wellbeing/).

Any information or personal details gathered in the study will remain confidential, except as required by law. Only the investigators named above will have access to the information obtained and no individual will be identified in any publication of the results. Upon completion of the study, a summary of the results will be posted outside the Chief Investigator's office (C3B 607) and on our research team's website <http://psy.mq.edu.au/lep/>.

Participants are free to withdraw from the study at any time, without consequence, and will receive your course credit.

If you have any food-related allergies, or more general allergies, to any household items, please contact the experimenter before attempting to complete the study.

Investigator's Name: Mem Mahmut

Investigator's signature:

Date

INVESTIGATOR'S/PARTICIPANT'S COPY

The ethical aspects of this study have been approved by the Macquarie University Human Research Ethics Committee. If you have any complaints or reservations about any ethical aspect of your participation in this research, you may contact the Committee through the Director, Research Ethics and Integrity (telephone (02) 9850 7854; email ethics@mq.edu.au). Any complaint you make will be treated in confidence and investigated, and you will be informed of the outcome.

*Appendix D***Relationship Questionnaire (RQ)**

(Bartholomew & Horowitz, 1991)

Following are four general relationship styles that people often report. Place a checkmark next to the letter corresponding to the style that best describes you or is closest to the way you are.

- A.** It is easy for me to become emotionally close to others. I am comfortable depending on them and having them depend on me. I don't worry about being alone or having others not accept me
- B.** I am uncomfortable getting close to others. I want emotionally close relationships, but I find it difficult to trust others completely, or to depend on them. I worry that I will be hurt if I allow myself to become too close to others.
- C.** I want to be completely emotionally intimate with others, but I often find that others are reluctant to get as close as I would like. I am uncomfortable being without close relationships, but I sometimes worry that others don't value me as much as I value them.
- D.** I am comfortable without close emotional relationships. It is very important to me to feel independent and self-sufficient, and I prefer not to depend on others or have others depend on me. Now please rate each of the relationship styles above to indicate how well or poorly each description corresponds to your general relationship style.

*Appendix E***Relationship Scales Questionnaire (RSQ)**

(Bartholomew & Horowitz, 1991)

Please rate each of the relationship styles above to indicate how well or poorly each description corresponds to your general relationship style.

Please answer the following questions using this 5-point response scale: from 1 (*not at all like me*) to 5 (*very much like me*)

- | | | |
|-----|--|--------------------|
| 1. | I find it difficult to depend on others. | <i>Fearful</i> |
| 2. | I find it easy to become emotionally close to others. | <i>Secure</i> |
| 3. | I worry that I will be hurt if I allow myself to become too close to others. | <i>Fearful</i> |
| 4. | I am comfortable without close emotional relationships. | <i>Dismissing</i> |
| 6. | I am uncomfortable without close emotional relationships. | <i>Preoccupied</i> |
| 7. | I want to be completely emotionally intimate with others. | <i>Preoccupied</i> |
| 8. | I worry about being alone. | <i>Secure</i> |
| 9. | I am comfortable depending on other people. | <i>Secure</i> |
| 10. | I find it difficult to trust others completely. | <i>Fearful</i> |
| 11. | I am comfortable having other people depend on me. | <i>Secure</i> |
| 12. | I worry that others don't value me as much as I value them. | <i>Preoccupied</i> |
| 13. | It is very important to me to feel self-sufficient. | <i>Dismissing</i> |
| 14. | I prefer not to have other people depend on me. | <i>Dismissing</i> |
| 15. | I am somewhat uncomfortable getting close to others. | <i>Fearful</i> |
| 16. | I find that others are reluctant to get as close as I would like. | <i>Preoccupied</i> |
| 17. | I prefer not to depend on others. | <i>Dismissing</i> |
| 18. | I worry about having others not accept me. | <i>Secure</i> |

*Appendix F***Questionnaire of Emotional Empathy (QMEE)**

(Mehrabian, & Epstein, 1972)

The following questions ask about your interaction style with other people and your reactions in various situations. Please answer the following questions using this 9-point response scale from 1 (*disagree very strongly*) to 9 (*agree very strongly*).

1. It makes me sad to see a lonely stranger in a group.
2. People make too much of the feelings and sensitivity of animals.
3. I often find public displays of affection annoying.
4. I am annoyed by unhappy people who are just sorry for themselves.
5. I become nervous if others around me seem to be nervous
6. I find it silly for people to cry out of happiness
7. I tend to get emotionally involved with a friend's problems.
8. Sometimes the words of a love song can move me deeply
9. I tend to lose control when I am bringing bad news to people.
10. The people around me have a great influence on my moods.
11. Most foreigners I have met seemed cool and unemotional.
12. I would rather be a social worker than work in a job training centre.
13. I don't get upset just because a friend is acting upset.
14. I like to watch people open presents.
15. Lonely people are probably unfriendly.
16. Seeing people cry upsets me.
17. Some songs make me happy.
18. I really get involved with the feelings of the characters in a novel.
19. I get very angry when I see someone being ill-treated.
20. I am able to remain calm even though those around me worry.
21. When a friend starts to talk about their problems, I try to steer the conversation to something else.

22. Another's laughter is not catching for me.
23. Sometimes at the movies I am amused by the amount of crying and sniffing around me
24. I am able to make decisions without being influenced by people's feelings.
25. I cannot continue to feel OK if people around me are depressed.
26. It is hard for me to see how some things upset people so much.
27. I am very upset when I see an animal in pain.
28. Becoming involved in books or movies is a little silly.
29. It upsets me to see helpless old people.
30. I become more irritated than sympathetic when I see someone in tears.
31. I become very involved when I watch a movie.
32. I often find that I can remain cool in spite of the excitement around me
33. Little children sometimes cry for no apparent reason.

*Appendix G***Depression, Anxiety & Stress (DASS-21)**

(Lovibond, 1995)

Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applies to you *much of the time*. There are no right or wrong answers. Do not spend too much time on any statement.

The rating scale is from: 1 (*does not apply to me at*) to 4 (*applies to me much of the time*)

- 1 I find it hard to wind down
- 2 I am aware of dryness of my mouth
- 3 I can't seem to experience any positive feeling at all
- 4 I experience breathing difficulty (eg, excessively rapid breathing, breathlessness in the absence of physical exertion)
- 5 I find it difficult to work up the initiative to do things
- 6 I tend to over-react to situations
- 7 I experience trembling (eg, in the hands)
- 8 I feel that I use a lot of nervous energy
- 9 I worry about situations in which I might panic and make fool of myself
- 10 I feel that I had nothing to look forward to
- 11 I find myself getting agitated
- 12 I find it difficult to relax
- 13 I find down-hearted and blue
- 14 I am intolerant of anything that kept me from getting on with what I am doing
- 15 I often feel close to panic
- 16 I am unable to become enthusiastic about anything
- 17 I feel I'm not worth much as a person
- 18 I feel that I am rather touchy
- 19 I am aware of the action of my heart in the absence of physical exertion (eg, sense of heart rate increase, heart missing a beat)
- 20 I feel scared without any good reason
- 21 I feel that life was meaningless

*Appendix H***Importance of Olfaction Scale (IOQ)**

(Croy, Buschhuter, Seo, Negoias, & Hummel, 2010)

This questionnaire refers to the role your sense of smell plays in your daily life. Please answer all of the questions spontaneously, there are no right or wrong answers.

The rating scale is from: 1 (*I totally disagree*) to 4 (*I totally agree*)

1. The smell of a person plays a role in the decision whether I like him/her
2. I smell foods to find out whether it is spoiled or not
3. I sniff on food before eating
4. Imagine you are at a museum. There is an offer to add smell presentation to enhance the experience for \$2. Would you take this offer?
5. When I don't like the smell of shampoo, I don't buy it
6. When I smell delicious food, I get hungry
7. I try to locate the odour when I smell something
8. I feel rather quickly disturbed by odours in my environment
9. Certain smells immediately activate numerous memories
10. Before drinking coffee/tea, I intentionally smell it
11. When I buy fruit/vegetables, I pay attention to their odour
12. If my partner has a nasty smell, I try to avoid kissing him/her
13. Certain smells immediately activate strong feelings
14. I smell my clothes to judge whether I have to wash them
15. When there is a nasty smell in the office/home of a colleague/friend, I leave the room as soon as possible
16. Certain odours can stimulate my fantasies
17. Sometimes I smell a person (et: my partner) to judge if they have been smoking or drinking
18. I cannot pass good smelling candles in a store without buying one

*Appendix I***Head Injury Interview**

1. Date: _____
 2. Participant No.: _____
 3. Date of Birth: _____
 4. Age: _____
 6. Country of Birth: _____
 7. Gender: Male / Female
 8. Handedness: Left / Right
 9. Education level: None / HSC / TAFE Course / Tertiary / Postgraduate
 10. Best language: _____
 11. Current occupation: _____
 12. Previous occupation (if retired/disabled/unemployed etc): _____
- Present Health:
13. Do you take prescription drugs routinely? ☐ No ☐ Yes (specify)
 14. Do you suffer from any allergies? ☐ No ☐ Yes (specify)
- Vision:
15. Do you wear glasses or contact lenses? ☐ No ☐ Yes (specify)
- Medical History:
16. Have you ever had nasal allergies or sinusitis? ☐ No ☐ Yes ☐ Unsure
If yes/unsure, give details: _____
 17. Have you ever had nasal or facial surgery? ☐ No ☐ Yes ☐ Unsure
If yes/unsure, give details: _____
 18. Have you ever had an accident/injury that affected any part of your face?
☐ No ☐ Yes ☐ Unsure
If yes/unsure, give details: _____
 19. Do you currently have a cold or flu? ☐ No ☐ Yes ☐ Unsure
If yes/unsure, give details: _____
 20. Are you currently suffering from nasal congestion? ☐ No ☐ Yes ☐ Unsure
If yes/unsure, give details: _____
 21. Any **current** problems with your sense of smell? ☐ No ☐ Yes ☐ Unsure
If yes/unsure, give details: _____
 22. Any **previous** problems with your sense of smell? ☐ No ☐ Yes ☐ Unsure
If yes/unsure, give details: _____
 23. Any **current** problems with your sense of taste? ☐ No ☐ Yes ☐ Unsure
If yes/unsure, give details: _____
 24. Any **previous** problems with your sense of taste? ☐ No ☐ Yes ☐ Unsure
If yes/unsure, give details: _____
 25. Do you **currently** smoke? ☐ No ☐ Yes If yes, give details: _____
 26. Have you ever smoked? ☐ No ☐ Yes If yes, give details: _____
 27. Have you ever been knocked unconscious? ☐ No ☐ Yes ☐ Unsure
If yes/unsure, give details: _____
 28. Have you ever been treated for a nervous condition? ☐ No ☐ Yes ☐ Unsure
If yes/unsure, specify when, where and give details: _____