Journal of Social, Evolutionary, and Cultural Psychology
2012, 6(4), 469-479.

Original Article

OLFACTORY ABILITY TO DETECT OVULATORY CUES: A FUNCTION OF BIOLOGICAL SEX, SEXUAL ORIENTATION, OR BOTH?

Grant T. Trouton
Amanda E. Guitar
Rachael A. Carmen
Glenn Geher
Terry L. Grandis
Department of Psychology, State University of New York at New Paltz

Abstract

For two decades, psychologists studying ovulation have successfully employed a series of "T-shirt studies" supporting the hypothesis that men can detect when a woman is most fertile based on olfactory detection of ovulatory cues. However, it is not known whether the ability to detect female fertility is primarily a function of biological sex, sexual orientation, or a combination of both. Using methodologies from previous T-shirt studies, we asked women not using hormonal contraceptives to wear a T-shirt for three consecutive nights during their follicular (ovulatory) and luteal (non-ovulatory) phases. Male and female participants of differing sexual orientations then rated the T-shirts based on intensity, pleasantness, and sexiness. Heterosexual males were the only group to rate the follicular T-shirts as more pleasant and sexy than the luteal T-shirts. Near-significant trends also indicated that heterosexual men and non-heterosexual women consistently ranked the T-shirts, regardless of menstrual stage, to be more intense, pleasant, and sexy than did non-heterosexual men and heterosexual women. Recommendations for future research, including suggestions for methodological changes, are discussed.

Keywords: Ovulation, sexual orientation, olfaction, pheromones

Introduction

Humans (and other animals) communicate with one another frequently throughout the day. While there is a surprising breadth of modalities that humans use to communicate, it is not uncommon to group these into one of two predominant forms of communication: explicit and implicit. Explicit communication involves the deliberate, conscious choosing of words and signals to convey a specific message to a recipient or target audience. Such examples include oral speech, written text, and even evolutionarily

AUTHOR NOTE: Please direct correspondence to Grant Trouton, Department of Psychology, State University of New York at New Paltz, 600 Hawk Dr., JFT 314, New Paltz, NY 12561. E-mail: gtrouton88@gmail.com

novel forms of communication such as e-mailing and using Facebook. Much of human communication is also implicit, and occurs subconsciously without overt individual attention. Examples include nonverbal communication and subconscious facial expressions, which have been argued to contribute significantly to human communication and understanding (Mehrabian & Ferris, 1967).

Additionally, recent studies conducted by evolutionary psychologists and biologists have revealed that other animals, including humans, may also communicate information implicitly via the production and detection of chemical olfactory cues. Of specific interest to evolutionary psychologists has been the investigation of human chemical cues indicating female reproductive status. These subliminally perceived chemical cues (odors) are often referred to as pheromones (Havlicek, Dvorakova, Bartos & Flegr, 2005; Savic & Berglund, 2010; Stern & McClintock, 1998). Pheromones are broadly defined as "airborne chemical signals that are released by an individual into the environment and which affect the physiology or behavior of other members of the same species" (Stern & McClintock, 1998, p. 177). While biologists have successfully identified and isolated sex pheromones from various insects (Prestwich, 1987), non-human mammals (such as mice, among others; Novotny, Ma, Wiesler, & Zidek, 1999), and have demonstrated sex pheromone induced brain activity in marmosets and other non-human primates (Snowdon, Ziegler, Schultz-Darken, & Ferris, 2006), isolation of sex pheromones in humans has not been successful. As such, a consensus has yet to be reached as to whether humans produce and detect pheromones at all (Hays, 2003), despite growing circumstantial evidence for their existence (Havlicek et al., 2005; Lenochova, Roberts, Havlicek, 2009; Miller & Maner, 2010; Poran, 1994; Singh & Bronstad, 2001). In light of this debate, we will refer more broadly to this form of communication as olfactory cues.

The Human Ovulatory Cycle

Evolutionarily, women's ovulatory cycles are of particular interest because ovulation is a critical yet visually occult component of reproduction. Though the length of the ovulatory cycle varies from individual to individual, the average length is about twenty-eight days. Within those twenty-eight days, the female body goes through the menses, follicular, and luteal phases (ovulation occurs at the end of the follicular phase; Stern & McClintock, 1998). In many primate species, the follicular (i.e., fertile) phase is explicitly expressed, as seen in baboons (Domb & Pagel, 2001) and chimpanzees, (Wallis, 1992) whose genitals undergo noticeable swelling to notify their fertile state. However, human females do not provide such obvious explicit cues and so for many years it was believed that the ability to visually detect ovulation was lost in humans over the course of evolution – i.e., concealed ovulation (Alexander, 1990; Fink, Hugill, & Lange, 2012; Haselton & Gildersleeve, 2011; Symons, 1979). Nevertheless, psychologists began investigating the possibility that humans could advertise and detect female ovulation via olfactory cues instead of visual cues.

Olfactory Cues of Ovulation

Recent studies suggest that women may have implicit indicators of fertility through the excretion of olfactory chemical cues as demonstrated by the preference that heterosexual men have for the body odor of women during the follicular phase of the

menstrual cycle than the luteal (i.e., non-fertile) phase (Havlicek et al., 2005; Poran, 1994; Singh & Bronstad, 2001). Additionally, Miller and Maner (2010) found that smelling T-shirts worn by ovulating women can increase testosterone levels in males, as compared to those who smelled the T-shirts worn by non-ovulating women or controlled odors. These "T-shirt studies" have collected female body odor using either under-arm cotton pads or by asking subjects to wear cotton T-shirts to bed to collect body odor while sleeping. Other independent subjects then sniff these T-shirts and rate them on traits such as intensity, pleasantness, and sexiness (Singh & Bronstad, 2001).

Additionally, these studies have proceeded under the assumption that both men and women benefit from detecting and signaling reproductive state, as such communication is believed to increase individual reproductive success (Buss, 2012). For heterosexual males, the benefit to ovulatory detection may be that they are able to detect fertile mates and therefore have more successful copulations resulting in increased numbers of offspring (Kuukasjarvi, Eriksson, Koskela, Mappes, Nissinen, & Rantala, 2004). However, the current literature lacks an explanation of the benefits received by non-heterosexual males, which research estimates account for anywhere from 1% to 15% of men (Diamond, 1993; Grulich, de Visser, Smith, Rissel, & Richters, 2003; Savin-Williams & Ream, 2007; Sell, Wells, & Wypij, 1995). Similarly, current literature is unclear about the perceived benefits for females to detect other females' ovulatory state (Haselton & Gildersleeve, 2011). For females, one theory is the female quality hypothesis, which proposes that increased levels of estrogen during fertile phases may signal to other females one's mate value and works as a subconscious form of intrasexual competition, or competition amongst women for potential mates (Haselton & Gildersleeve, 2011). Despite this theory, most "T-shirt studies" find that females do not show a difference in ratings of shirts collected from women during fertile and non-fertile times (Havlicek et al., 2005; Poran, 1994; Singh & Bronstad, 2001; for an exception, see Kuukasjarvi et al., 2004).

Present Study

Though the implications of the previous T-shirt studies are revealing, current literature has nevertheless failed to address the role of sexual orientation on an individual's ability to detect these ovulatory cues. Particularly, the sexualities of male subjects rating the scent of females' T-shirts have not been examined (for examples of research along these lines that has neglected to examine sexual orientation, see Havlicek et al., 2005; Miller & Maner, 2010; Poran, 1994; Singh & Bronstad, 2001; Thornhill & Gangestad, 1999). Since non-heterosexual males are less inclined to mate with females than their heterosexual counterparts, it is not unreasonable to suspect that such olfactory communication might decrease in relevance for males with less heterosexual inclinations. In other words, female olfactory cues indicating fertility should be of most importance for predominantly heterosexual males, and of least importance to predominantly homosexual males. To fill this research gap, this study examines olfactory perceptive abilities of female ovulation as a function of biological sex and sexual orientation.

Hypotheses

Since female ovulation contains specific reproductive information that should theoretically be of most value to heterosexual males, we hypothesize that among men, (1)

only heterosexuals will provide higher intensity, pleasantness, and sexiness ratings for follicular phase T-shirts than for luteal phase T-shirts. Since female production of olfactory cues is highest during the follicular phase of the menstrual cycle, we also hypothesize that among men, (2) ratings of intensity, pleasantness, and sexiness provided by heterosexual subjects should be higher than the ratings provided by homosexual subjects for follicular T-shirts, but not for luteal T-shirts. Finally, we hypothesize that among women, (3) participants should provide similar intensity, pleasantness, and sexiness ratings for both follicular and luteal T-shirts regardless of sexual orientation.

Method

Participants

Volunteers were recruited from the State University of New York at New Paltz's campus-wide student email, as well as the Psychology department subject pool. Subjects were offered the choice of a $5 Starbucks gift card or 4 research credits (Psychology undergraduates only) for their participation in the study.

A total of 17 women (M_{age} = 22.8, *SD* = 6.4 years) not on hormonal birth control completed the month-long research protocol and provided T-shirts for analysis. A total of 53 separate undergraduates (M_{age} = 23.2, *SD* = 5.7 years) volunteered as T-shirt raters. Of these, 20 were classified as heterosexual males, 13 as non-heterosexual males, 12 as heterosexual women, and 8 as non-heterosexual women. Responses to the question: "To whom are you sexually attracted?" (1 = other sex only to 7 = same sex only) were used to categorize individuals by sexual orientation since this response was deemed least likely to be affected by sexual availability or societal influence, and therefore most representative of actual biological attraction. Since most participants recorded his or her sexuality as either a "1" or "7" with minimal scores in-between, the decision was made to dichotomize sexuality, rather than treating it as a continuous variable. Initially, individuals recording a 1 or 2 were categorized as predominantly "heterosexual", those recording a 3-5 were categorized as predominantly "bisexual", and those recording a 6 or 7 were categorized as predominantly "homosexual." However, a low sample size of bisexual men and women prompted us to combine individuals recording a 3-7 into the category of "non-heterosexual" for analysis.

Materials and Procedure

Odor-Collection Procedure for T-shirt Wearers. Body odor samples were collected using a procedure identical to that of Singh and Bronstad (2001). Female participants were provided with two folded and previously unworn, washed, and dried Fruit of the Loom white cotton T-shirts, each in its own plastic Ziploc bag, along with a 3 oz. bottle of unscented shampoo, a bar of unscented Dove soap, half a stick of unscented Sure deodorant, and two small plastic Ziploc bags of unscented Tide detergent. To keep the T-shirts anonymous, participants were asked to make up and write a five-digit personal code on the plastic bags with permanent marker (provided). Each code contained either the prefix "F" or "L" to distinguish between T-shirts worn during the follicular (F) and luteal (L) phases of the woman's menstrual cycle. Participants were then given written instructions on remaining "odor neutral," on calculating which nights to wear the T-shirt, and on wearing the T-shirt.

To remain "odor neutral," participants were required to refrain from the following on days/nights of T-shirt use: scented soaps, deodorant and fragrances (perfume, cologne, aftershave), pungent foods (garlic, green chile, pepperoni, pungent spices, herbs, strong cheeses, cabbage, celery, asparagus, yogurt, and lamb), drinking alcohol, using recreational drugs, smoking tobacco, having sexual intercourse with another person, or sleeping with pets.

Participants were also given instructions for calculating which nights to wear each T-shirt. Treating their most recent menstruation (marked by menstrual blood-spotting) as day "0," they were asked to count out to days 13, 14, and 15 and mark these on a calendar as the days to wear the T-shirt to sleep from the bag marked with an "F" (follicular phase). They were instructed to continue counting out to days 20, 21, and 22, on which to wear the T-shirt to sleep from the bag marked with an "L" (luteal phase).

On the first day of the three-night follicular phase session (day 13), participants were asked to wash their bed sheets and pillow covers with the unscented detergent provided. Each night, they were also instructed to shower/bathe using the unscented soap and shampoo provided immediately prior to wearing the T-shirt. The T-shirt from the bag marked with an "F" was then worn in direct contact with the skin while sleeping. Upon awaking the next morning, participants sealed the shirt back in the Ziploc bag. Participants wore the same shirt to bed the following two nights (days 14 and 15 of the menstrual cycle). At the end of the session, the sealed T-shirts were immediately returned to the researchers and frozen in a campus freezer to prevent odor degradation (Lenochova et al., 2009). Each participant repeated this procedure during the luteal phase of her cycle (days 20, 21, and 22), wearing the T-shirt marked with an "L."

Finally, it is important to note that across T-shirt providers, T-shirts worn during the follicular and luteal phases of the menstrual cycle were not always turned into the researchers in the same order. At the time of T-shirt distribution, some female participants were closer to the follicular phase, and thus turned in an (F) shirt first, while others were closer to the luteal phase, and thus turned in an (L) shirt first. Therefore, we suspected no systematic biases between (F) and (L) shirts regarding order effects. Additionally, no biases were suspected due to subsequent length of T-shirt storage time, as ratings for intensity, pleasantness, and sexiness remained stable over a six-month storage time despite numerous freezings and thawing in previous studies (Lenochova et al., 2009).

Odor-Attractiveness Rating Procedure. Body odor ratings were also obtained using a procedure similar to that of Singh and Bronstad (2001). All T-shirts were removed from the freezer and were allowed to thaw for ~2-3 hours before being rated. Each of the 18 pairs of T-shirts (17 pairs of worn T-shirts, and 1 pair of unworn T-shirts with a fake five-digit code used as a control) were then randomly sorted into one of four numbered Tupperware storage "bins". As part of their consent for participation, raters were informed that the T-shirts they were to rate had been worn by women (as per Singh and Bronstad, 2001). Groups of raters were then brought into a large classroom and seated at individual desks spaced along the walls facing outward away from other raters. Since participants were unable to see each other's ratings and were instructed not to discuss the procedure with other raters, group-testing biases were not believed to influence the T-shirt ratings.

Bins were randomly circulated among the participants in order to facilitate random presentation of the T-shirts. Participants then removed a bag from the bin, unzipped it, and sniffed the T-shirt. Touching the T-shirts with any part of the body was

prohibited, as this would have contaminated the T-shirt odors. After sniffing, the bags were resealed, placed back in the bin, and the T-shirts were rated on three different scales of attractiveness: pleasantness (1 = very unpleasant to 10 = very pleasant), intensity (1 = not intense at all to 10 = very intense), and sexiness (1 = very unsexy to 10 = very sexy). These scales were provided on each participant's rating sheet, which was divided by bin number to facilitate ease of locating each shirt on the rating sheet. Participants continued to sniff all T-shirts one bin at a time until all 18 pairs (36 T-shirts total) were rated. Raters then filled out the Klein Sexuality Grid (Klein, 1993), and a general demographics questionnaire.

Results

In an attempt to replicate past findings demonstrating that men find the body odor of women to be more attractive during the follicular (fertile) phase of the menstrual cycle than the luteal (non-fertile) phase (Havlicek et al., 2005; Poran, 1994; Singh & Bronstad, 2001), we analyzed the ratings of all men, regardless of sexual orientation, using a within-samples *t*-test. Follicular phase T-shirts were rated as being more pleasant (M = 4.42, SD = 1.06) than luteal phase T-shirts (M = 4.24, SD = 1.01), $t(32) = 2.60$, p = .014, d = .45 (see Table 2), and more sexy (M = 3.86, SD = 1.39) than luteal T-shirts (M = 3.61, SD = 1.30), $t(32) = 2.81$, p = .008, d = .49 (see Table 3). Second, we re-ran this analysis as a function of sexual orientation, separating the heterosexual males (n = 20) from the non-heterosexual males (n = 13). Results remained significant for heterosexual males, as the follicular-phase T-shirts were rated as being more pleasant (M = 4.66, SD = 0.88) than luteal phase T-shirts (M = 4.39, SD = 0.85), $t(19) = 2.79$, p = .012, d = .62 (see Table 2), and more sexy (M = 4.09, SD = 1.35) than luteal phase T-shirts (M = 3.77, SD = 1.27), $t(19) = 2.51$, p = .021, d = .56 (see Table 3). Non-heterosexual men also rated follicular-phase T-shirts to be more intense, pleasant, and sexy than luteal-phase T-shirts, although these results were not significant (see Tables 1, 2, and 3). A power analysis using G*Power 3.1.3 software was then conducted to determine our obtained power for the non-heterosexual male subjects on ratings of pleasantness and sexiness. Obtained power for pleasantness and sexiness was 0.08 and 0.22, respectively. As such, the likelihood of finding significant effects was relatively small. Assuming a medium effect size of 0.5, this analysis also revealed that we would have required a sample of at least n = 34 non-heterosexual male subjects (compared to our n = 13) to obtain the desired power level of 0.80.

To test our primary hypothesis that men's ability to prefer the follicular phase over the luteal phase is a function of sexuality, we conducted an ANOVA to examine the interaction between sexual orientation and menstrual phase among men. Results for intensity, pleasantness, and sexiness ratings were all non-significant, and no trends were observed (all p-values > .10). To test for gender effects, a 3-way ANOVA was then conducted to look for a menstrual phase-by-gender-by-sexual orientation interaction. While none of the interactions or main effects were significant, a pattern of marginally significant gender-by-sexual orientation interactions nevertheless emerged for all three ratings of attractiveness. Specifically, we found possible gender-by-sexual orientation interactions for intensity ratings, $F(1,49) = 4.00$, p = .051, η^2 = .076, pleasantness ratings, $F(1,49) = 3.73$, p = .059, η^2 = .071 and sexiness ratings, $F(1,49) = 2.83$, p = .099, η^2 = .055. Heterosexual males and non-heterosexual females provided higher ratings of intensity, pleasantness, and sexiness than non-heterosexual males and heterosexual

females (see Tables 1, 2, and 3). Based on the exploratory nature of this study and the consistent nature of the observed data, we decided to conduct post-hoc tests on these means even though strict statistical significance was not observed in the gender-by-sexual orientation interactions. While no differences were found for ratings of pleasantness or sexiness, non-heterosexual females provided higher intensity ratings (M = 5.20, SD = 1.31) than both heterosexual males (M = 4.01, SD = 1.41), $t(26) = -2.06$, $p = .050$, d = 2.06 and non-heterosexual males (M = 3.64, SD = 1.24), $t(19) = -2.74$, $p = .013$, $d = 2.74$ (see Table 1).

Table 1. Mean Intensity Ratings

	Men			Women		
Phase	Hetero	Non-Hetero	Combined	Hetero	Non-Hetero	Combined
Follicular	4.04(1.45)	3.71(1.28)	3.91(1.37)	3.96(1.62)	5.16(1.35)	4.44(1.60)
Luteal	3.98(1.43)	3.57(1.24)	3.82(1.35)	3.94(1.60)	5.24(1.31)	4.46(1.59)
Average	$4.01(1.41)_a$	$3.64(1.24)_a$	3.86(1.35)	3.95(1.57)	$5.20(1.31)_b$	4.45(1.58)

Note: "Hetero" and "Non-Hetero" are abbreviations for Heterosexual and Non-Heterosexual, respectively. "Average" refers to the column averages. Standard deviations are shown in parentheses. Results of two-tailed tests: Means with different subscripts are significantly different from each other at the $p < .05$ level (except that the p-level for the contrast between 4.01 and 5.20 = .05).

Table 2. Mean Pleasantness Ratings

	Men			Women		
Phase	Hetero	Non-Hetero	Combined	Hetero	Non-Hetero	Combined
Follicular	$4.66(0.88)_a$	4.04(1.23)	$4.42(1.06)_b$	3.89(1.04)	4.57(1.17)	4.16(1.12)
Luteal	$4.39(0.85)_a$	4.00(1.22)	$4.24(1.01)_b$	3.99(1.23)	4.59(1.06)	4.23(1.17)
Average	4.53(0.84)	4.02(1.21)	4.33(1.03)	3.94(1.09)	4.58(1.05)	4.20(1.13)

Note: "Hetero" and "Non-Hetero" are abbreviations for Heterosexual and Non-Heterosexual, respectively. "Average" refers to the column averages. Standard deviations are shown in parentheses. Results of two-tailed tests: $_a$Means within a column are significantly different from each other at the $p < .05$ level. $_b$Means within a column are significantly different from each other at the $p < .05$ level.

Table 3. Mean Sexiness Ratings

	Men			Women		
Phase	Hetero	Non-Hetero	Combined	Hetero	Non-Hetero	Combined
Follicular	$4.09(1.35)_a$	3.51(1.44)	$3.86(1.39)_b$	3.28(1.04)	4.07(1.42)	3.60(1.24)
Luteal	$3.77(1.27)_a$	3.38(1.37)	$3.61(1.30)_b$	3.34(1.15)	4.04(1.26)	3.62(1.22)
Average	3.93(1.28)	3.44(1.39)	3.74(1.34)	3.31(1.07)	4.06(1.29)	3.61(1.21)

Note: "Hetero" and "Non-Hetero" are abbreviations for Heterosexual and Non-Heterosexual, respectively. "Average" refers to the column averages. Standard deviations are shown in parentheses. Results of two-tailed tests: $_a$Means within a column are significantly different from each other at the $p < .05$ level. $_b$Means within a column are significantly different from each other at the $p < .01$ level.

Discussion

From an evolutionary perspective, the prevalence of homosexuality is intriguing, as homosexual individuals consistently produce fewer offspring than their heterosexual

counterparts (Bell & Weinberg, 1978; for review, see Wilson & Rahman, 2005). Understanding the nature of this sub-population is important to help us understand the evolutionary origins of a major feature of humanity (sexual orientation). Evidence which suggests that homosexual individuals respond differently (or similarly) to heterosexuals in the mating domain sheds light on which features of sexual orientation are specific to a suite of attributes of sexual orientation versus qualities that are more likely to be gender-specific or species (human) specific.

A quickly accumulating body of research suggests that heterosexual men do in fact find a woman to smell more attractive when she is in a fertile phase than when she is in a non-fertile phase (Havlicek et al., 2005; Poran, 1994; Singh & Bronstad, 2001). Thus, any research attempting to expand from this premise must also replicate that finding. Indeed, we were able to demonstrate that college-aged heterosexual men found women to smell more pleasant and sexy during estimated peak fertility. Our ability to replicate past results indicates that the procedures employed in this study were methodologically sound.

We then attempted to investigate if, like their heterosexual counterparts, non-heterosexual men would also find T-shirts worn during the follicular phase to smell more intense, pleasant, and sexy than T-shirts worn during the luteal phase. However, the likelihood of finding significant ratings from these subjects consistent with the ratings provided by male heterosexuals was only 8% for pleasantness ratings and 22% for sexiness ratings. Specifically, we would have required an additional 21 non-heterosexual males to obtain an 80% chance of detecting the ability to discriminate between follicular and luteal phase T-shirts. This was primarily due to the small sample size of non-heterosexual men (n = 13). Similarly small sample sizes of heterosexual women (n = 12) and non-heterosexual women (n = 8) likely precluded us from obtaining significant findings in the overall 3-way ANOVA (clearly, per our analyses, this was an issue of statistical power). In any event, the trend that non-heterosexual males found the follicular T-shirts to smell more intense, pleasant, and sexy than luteal T-shirts seems to support this possibility. Finally, small sample sizes also forced us to dichotomize sexuality rather than treat is as a continuous variable. In theory, this could also have contributed to a reduction in statistical power, preventing us from discerning any small or medium-sized effects. As such, small sample sizes were the primary limitations of this study.

Results from the overall ANOVA also suggested marginally significant gender-by-sexual orientation interactions for intensity, pleasantness, and sexiness ratings, regardless of T-shirt phase. Specifically, heterosexual men and non-heterosexual women consistently rated the T-shirts higher in all three categories than non-heterosexual males and heterosexual women. We propose two possible explanations for this observation. First, this could be a logical finding, as heterosexual men and non-heterosexual women are indeed the two groups of individuals most attracted to women as a whole. However, in an attempt to keep our methodology consistent between the raters and with previous studies (Singh & Bronstad, 2001) all 53 raters were informed that the T-shirts they were to sniff had been worn by women. This could have had the unintended consequence of artificially inflating the ratings provided by non-heterosexual women, and deflating the ratings provided by non-heterosexual men. Indeed, multiple non-heterosexual males gave apologies – both in the open comments section of the questionnaire and freely after the study concluded – for what they considered to be low ratings, citing presumptive lack of attraction to the females who wore the T-shirts. Similarly, this knowledge would have biased female non-heterosexuals towards providing higher ratings. Therefore, we also

believe this trend may not be a reliable finding, but may be due to a systematic cognitive bias stemming from the knowledge that the T-shirts were worn by women.

The most common complaint the raters reported on the free-response section of the questionnaire (and during the study itself) was that the smell of the plastic Ziploc bag was overwhelming the smell of the T-shirts, making it difficult to provide accurate "intensity" ratings. Indeed, no differences in intensity were found for this study or for Singh and Bronstad (2001), from which our methodology was co-opted. Therefore, T-shirt studies using plastic bags for storage may have predictable, loss of significance effects on intensity ratings. It is, however, important to note that despite these objections, significance has consistently been found for pleasantness and sexiness in prior studies employing the plastic bags, as well as for the present study. Nevertheless, it may be worth revising future T-shirt studies by possibly storing T-shirts in glass jars or another medium that can still retain the T-shirt odors after numerous freezing and thawing (Lenochova et al., 2009). Finally, individual variation in menstrual cycle length was not accounted for. All participants were assumed to have a 28-day cycle, in which they ovulated around the 14th day after their menstrual spotting began. Future research should take this variability into account.

In conclusion, future research on this topic would benefit from the following: (1) a sufficiently large sample size of non-heterosexual males and females to increase the likelihood of finding small effect sizes, (2) a modified methodology in which T-shirt raters are unaware of the sex of the population that wore the T-shirts, and (3) storage of the T-shirts in non-plastic containers. Such research will be crucial to understanding whether the ability to detect olfactory cues indicative of high fertility are a function of biological sex, sexual orientation, or a combination of both. Our results support previous findings that heterosexual men are able to detect a difference in olfactory cues provided by women during various phases of the ovulatory cycle. While a small sample size may have affected our results, our findings nevertheless suggest that future studies and investigations in this area are warranted.

Received July 15, 2012; Revision received October 11, 2012; Accepted October 31, 2012

Acknowledgments

We would like to thank Dr. Jennifer Waldo of SUNY New Paltz for providing us with the freezer to store our T-shirts, and Dr. Douglas C. Maynard of SUNY New Paltz for assisting with statistical analysis. Funding for this project was provided by the SUNY New Paltz Spring-Summer 2012 Research and Creative Projects Award.

References

Alexander, R. (1990). *How did humans evolve? Reflections on the uniquely unique species*. Ann Arbor, Michigan: The University of Michigan Zoology Museum Special Publication.

Bell, A. P., & Weinberg, M. S. (1978). *Homosexualities: A study of diversity among men and women*. New York: Simon & Schuster.

Buss, D. M. (2012). *Evolutionary Psychology: The new science of the mind* (4th ed.). Boston, MA: Pearson Education, Inc.

Diamond, M. (1993). Homosexuality and bisexuality in different populations. *Archives of Sexual Behavior*, *22*, 291-310.

Domb, L. G., & Pagel, M. (2001). Sexual swellings advertise female quality in wild baboons. *Nature*, *410*(6825), 204-206. doi:10.1038/35065597

Fink, B., Hugill, N., & Lange, B. P. (2012). Women's body movements are a potential cue to ovulation. *Personality & Individual Differences*, *53*(6), 759-763. doi:10.1016/j.paid.2012.06.005

Grulich, A. E., de Visser, R. O., Smith, A. M. A., Rissel, C. E., & Richters, J. (2003). Sex in Australia: Homosexual experience and recent homosexual encounters. *Australian and New Zealand Journal of Public Health*, *27*, 155-163.

Haselton, M. G., & Gildersleeve, K. (2011). Can men detect ovulation? *Current Directions in Psychological Science*, *20*(2), 87-92. doi:10.1177/0963721411402668

Havlicek, J., Dvorakova, R., Bartos, L., & Flegr, J. (2005). Non-advertised does not mean concealed: Body odour changes across the human menstrual cycle. *Ethology*, *112*(1), 81-90. doi:10.1111/j.1439-0310.2006.01125.x

Hays, W. S. T. (2003). Human pheromones: Have they been demonstrated? *Behavioral Ecology and Sociobiology*, *54*(2), 89-97.

Klein, F. (1993). *The bisexual option* (2nd ed.). Binghamton, NY: The Haworth Press.

Kuukasjärvi, S., Eriksson, C., Koskela, E., Mappes, T., Nissinen, K., & Rantala, M. J. (2004). Attractiveness of women's body odors over the menstrual cycle: The role of oral contraceptives and receiver sex. *Behavioral Ecology*, *15*(4), 579-584. doi:10.1093/beheco/arh050

Lenochova, P., Roberts, S. C., & Havlicek, J. (2009). Methods of human body odor sampling: the effect of freezing. *Chemical Senses*, *34*, 127-138.

Mehrabian, A., & Ferris, S.R. (1967). Inference of attitudes from nonverbal communication in two channels. *Journal of Consulting Psychology*, *31*(3), 248-252.

Miller, S. L., & Maner, J. K. (2010). Scent of a woman: Men's responses to olfactory ovulation cues. *Psychological Science*, *21*, 276-283.

Novotny, M. V., Ma, W., Wiesler, D., & Zidek, L. (1999). Positive identification of the puberty-accelerating pheromone of the house mouse: The volatile ligands associating with the major urinary protein. *Proceedings: Biological Sciences*, *266*(1432), 2017-2022.

Poran, N. S. (1994). Cyclic attractivity of human female odors. *Advanced Bioscience*, *93*, 555-560.

Prestwich, G.D. (1987). Chemistry of pheromone and hormone metabolism in insects. *Science*, *237*(4818), 999-1006.

Savic, I., & Berglund, H. (2010). Androstenol – a steroid derived odor activates the hypothalamus in women. *Plos one*, *5*(2), 1-5.

Savin-Williams, R.C., & Ream, G.L. (2007). Prevalence and stability of sexual orientation components during adolescents and young adulthood. *Archives of Sexual Behavior*, *36*(3), 384-394.

Sell, R.S., Wells, J.A., & Wypij, D. (1995). The prevalence of homosexual behavior and attraction in the United States, the United Kingdom and France: results of national population-based samples. *Archives of Sexual Behavior*, *24*(3), 235-248.

Singh, D., & Bronstad, P. M. (2001). Female body odour is a potential cue to ovulation. *Proceedings of the Royal Society of London B: Biological Sciences*, *268*, 797-801.

Snowdon, C.T., Ziegler, T.E., Schultz-Darken, N.J., & Ferris, C.F. (2006). Social odours, sexual arousal and pairbonding in primates. *Philosophical Transactions: Biological Sciences*, *361*(1476), 2079-2089.

Stern, K., & McClintock, M. K., (1998). Regulation of ovulation by human pheromones. *Nature, 392*, 177-179.

Symons, D. (1979). The evolution of human sexuality. New York: Oxford University Press.

Thornhill, R., & Gangestad, S. W. (1999). The scent of symmetry: A human sex pheromone that signals fitness? *Evolution and human behavior, 20,* 175 –201.

Wallis, J. (1992). Chimpanzee genital swelling and its role in the pattern of sociosexual behavior. *American Journal of Primatology, 28*, 101-113.

Wilson, G.D., & Rahman, Q. (2005). *Born gay? The psychobiology of sexual orientation*. London: Peter Owen Press.