# THE BEHAVIORAL ECOLOGY OF ESTRUS SIGNALING IN HUMANS

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# RESEARCH PROPOSAL

When female primates are the most fertile, they show it by a swelling of the estrus, which is easily visible to other primates. The purpose of this is to demonstrate to male primates when the females are most likely to conceive, and therefore to reveal the best time for copulation. Human females, on the other hand, do not express as obvious of clues as to when they are the most fertile. As of recent, general knowledge has been that female humans have concealed ovulation, but there have been several studies that seem to prove otherwise. My senior project question is: is human ovulation really concealed?

There are many studies showing that when a woman goes through her menstrual cycle each month, several behavioral and physical changes occur in coordination with her fertility level. As a woman becomes more fertile, these changes make her more attractive to males, which increases copulation opportunities and therefore makes pregnancy more likely. Non-concealed ovulation is evolution's way of ensuring copulation at a time when women are at peak fertility.

Though we are consciously unaware of the changes that women go through when they are near ovulation, there are actually several physical and behavioral signals. A woman's voice will get higher and more feminine, and her face will become more attractive to males by becoming more symmetrical. Also, a woman's breasts become more symmetrical and her odor changes, becoming more attractive to males. Along with these biological changes, a woman also begins behaving differently. She will become more flirtatious and more likely to go to social events where there will be single males. She is also more likely to dress in a revealing fashion and to wear more jewelry to call attention to herself. Also, what a woman finds attractive in a mate changes when she is fertile; she is not looking for qualities that would be good in a long-term mate, instead looking for good qualities for a short-term mate. Ovulation also causes women to be more willing to pursue short-term mating strategies like a "one night stand".

These biological and behavioral changes in women during their peak fertility all have an evolutionary purpose: to become more attractive to males. Though these changes are subtle, and both males and females are largely unaware that they are occurring, subconsciously males notice the difference in ovulating females.

# **ANNOTATED BIBLIOGRAPHIES**

Bryant, G. A., & Haselton, M. G. (2009). Vocal cues of ovulation in human females. *Biology Letters*, *5*, 12-15.

In "Vocal cues of ovulation in human females", Bryant and Haselton predict that sexually dimorphic vocal cues would vary depending on a woman's fertility. They did a study with 69 normally cycling, non-pill using women who came in to take tests at low fertility (luteal phase) and at high fertility (follicular phase). Their voices were recorded on a digital recorder in the form of a sentence ("Hi, I'm a student at UCLA") and particular vowel sounds. The samples measured frequency (pitch), formant dispersion, jitter, shimmer, harmonics-to-noise ratio and speech rate.

For the spoken sentences, high-fertility recordings were significantly higher in pitch than low-fertility recordings. The recording pairs were also played to 15 participants who were instructed to choose the recording with the higher pitch. The participants picked the higher pitch recording 55% of the time.

The authors' hypothesis was verified; female voices get higher, and therefore more attractive and more feminine to male ears, at stages of high fertility. This is a perceptible sign of ovulation in females, disproving the theory that female human ovulation is concealed.

Roberts, S. Craig, Klapilova, Katerina, Little, Anthony C., Burriss, Robert P., Jones, Benedict C., DeBruine, Lisa M., Petrie, Marion, & Havlicek, Jan (2011).

Relationship satisfaction and outcome in women who meet their partner while using oral contraception. Proceedings of the Royal Society.

Roberts et. al's article "Relationship satisfaction" discusses how women using hormonal contraceptives may choose their partners differently than non-using women. Because non-using women often choose men who are not MHC-similar to themselves, women who are on the pill may choose men who are MHC similar, and therefore have different relationship outcomes. Craig et. al. did a study involving 2519 women (some on the pill and some not) who had all had at least one child. Then the authors asked the women questions pertaining to their sexual satisfaction with their partner (or ex-partner), about their general satisfaction in their relationship, sexual rejection and compliant sex with their partner, attractiveness of their partner, ratings of their ex-partners, and their experience and attitudes toward extra-pair sex.

The results showed that for women in a relationship, women on the pill at the time of partner choice scored lower on sexual arousal, satisfaction with his sexual adventurousness, attraction towards him, and sexual proceptivity compared to non-users. However, pill users rated higher on general satisfaction and financial provision satisfaction. The women who weren't in a relationship recalled similar results, and also were more likely to have initiated the separation compared with non-users. In general, though, pill-users had a lower separation rate and generally longer relationships. Birth control, therefore, may be a factor in mate choice.

Bullivant, S., Sellergren, S., Stern, K., Spencer, N., Jacob, S., et al. (2004). Women's sexual experience during the menstrual cycle: Identification of the sexual phase by noninvasive measurement of luteinizing hormone. *Journal of Sex Research*, *41*(1), 82-93.

"Women's sexual experience during the menstrual cycle" is composed of two significant parts. In the first part, the authors do a study of women in order to figure out exactly when the preovulatory surge of Luteinizing Hormone occurs. The authors wanted to figure out when this LH surge occurs in order to see when a woman is most fertile. They did this by collecting urine samples and instructing women to take their Basal Body Temperature.

Once the authors figured out when the women were the most fertile, they hypothesized that more fertile women would initiate sexual activity more often, and have more sexual fantasies. Participants were asked to fill out a lot of personal information about health and sexual activities and such, and also asked whether they had engaged in sexual activity that day (with someone or alone), and asked who initiated that activity. The results showed that rate of sexual activity increased prior to the LH surge onset and remained high for a few days afterward. Sexual activity was highest during the follicular phase of the menstrual cycle and lowest during the first three days of menstruation. Next, the authors studied data from 46 women and looked at sexual activity, sexual desire, sexual fantasies, loneliness, and partnership status. Women with partners reported more sexual fantasies during the ovulatory phase. Highly fertile women were more likely to initiate sexual activity, have stronger desire, and have more fantasies.

Miller, G., Tybur, J., & Jordan, B. (2007). Ovulatory cycle effects on tip earnings by lap dancers: economic evidence for human estrus? *Evolution and Human Behavior*, 28(6), 375-381. Elsevier. Retrieved from

http://linkinghub.elsevier.com/retrieve/pii/S1090513807000694

Geoffrey Miller, Joshua Tybur, and Brent Jordan's "Ovulatory cycle effects of tip earnings by lap dancers: economic evidence for human estrus" discusses how the view that estrus is hidden in females can be disputed. The authors did a study involving the amount of tips earned by 18 normally ovulating dancers in gentlemen's clubs while they were ovulating as compared to dancers who were not ovulating. They measured these tip earnings over a two month span.

The dancers at the club they studied wear bottoms while they dance, so their menstruation is concealed. The women's cycles were broken up into 3 phases: the menstrual, fertile, and luteal phase. The authors predicted that the women on birth control would make less in tips than the women who were regularly cycling. They found that this was true in all stages of the women's cycles. In all three phases, the normally cycling women made more in tips than the pill users. Also, women who were in the fertile phase made more tips than when they were in their menstrual or luteal phases, and made more in their luteal phase than in their menstrual phase.

Pill users made about \$193 per shift, while normally cycling women made about \$276 per shift, which means a loss of \$80 per shift for pill using women. This shows that men, likely unknowingly, can sense when women are more fertile and find it more attractive than when they aren't fertile.

Pillsworth, E., Haselton, M., & Buss, D. (2004). Ovulatory shifts in female sexual desire. *Journal of Sex Research*, 41(1), 55-65.

"Ovulatory shifts in female sexual desire" by Pillsworth, Haselton, and Buss delves into the evolutionary psychology surrounding ovulation and female sexual desire. The authors wanted to know whether women experience more sexual desire at the time of their highest fertility, and want to know how this relates to relationships. They hypothesize two things; one, that women get more sexually desirous when they are more likely to conceive, and that mated women will feel the effects of this more strongly, and two, that women who are mated and not happy with that mate are more likely to desire extra-pair copulations as they get more fertile.

The authors conducted a study where they asked 173 women many detailed questions about the status of their relationship as well as their menstrual history. A factor that could likely have affected the study is that 65% of the women were virgins, even some who were in relationships. The women who were in relationships but hadn't had sex with their partner were more likely to report extrapair desires. The authors found that differences in fertility predicted a change in sexual desire only among mated women. There wasn't a relationship between fertility and sexual desire for unmated women. The authors also found that women who were satisfied in their relationships were less likely to desire extra-pair partners, and women who were not satisfied were more likely to have extra-pair desires during high fertility. Women happy in their relationships did experience higher sexual desire for their partner during ovulation.

Roberts, S., Havlicek, J., Flegr, J., Hruskova, M., Little, A., et al. (2004). Female facial attractiveness increases during the fertile phase of the menstrual cycle.

*Proceedings: Biological Sciences, 271,* S270-S272.

It has been previously believed that ovulation is hidden in human females, but now there is evidence to the contrary. "Female facial attractiveness increases during the fertile phase of the menstrual cycle" by Roberts et. al. discusses how female's faces become more attractive to males when the females are more fertile. The study the authors did involved 48 women from the UK and the Czech Republic who were all normally cycling (no birth control). The researchers took two pictures of the women, once when they were in their follicular phase (fertile phase) and once when they were in their luteal (non-fertile) phase. These women all wore no makeup and were in front of a plain white background, and wore a neutral expression. Then these image pairs were shown to 63 men and 61 women who were instructed to choose which photo they found more attractive.

The authors predicted that the men in the study would choose the picture of the woman being rated in her fertile phase, as opposed to her luteal phase. The raters had to look at the image pairs where the woman was masked (obscured hairstyle and condition) and unmasked. Overall, female raters chose the fertile images of the women more often, whether they were masked or unmasked. However, both males and females chose the fertile photos of the women more than 50% of the time, showing that there is a change in female facial appearance due to changes in the menstrual cycle.

Gangestad, S., & Thornhill, R. (1998). Menstrual cycle variation in women's preferences for the scent of symmetrical men. *Proceedings: Biological Sciences*, 265(1399), 927-933.

In this study, authors Gangestad and Thornhill wanted to research not how women smell during follicular and luteal phases of their cycles, but instead how women react to the smell of a man depending on their stage in their cycle. The authors predicted that ovulating women would prefer the scent of men who are more symmetric to those who are not as symmetric. The authors used FA (fluctuating asymmetry) as the factor determining how symmetric the men were. They discussed how men with low FA experience greater mating success and more sexual partners.

The study had 42 men and 52 women (though only 28 women were actually used in the end). The men were measured for symmetry, and the women reported where they were in their menstrual cycle. The men had to wear clean t-shirts for two nights and then put the t-shirts into freezer bags. The experiment was controlled for invasive smells. The women were then asked to smell the shirts and rate them based on sexiness, intensity, and pleasantness. The authors found that the more symmetrical the man was, the more attractive his smell would be to women who were at high-fertility risk. Women at low fertility didn't favor the scents of symmetrical nor non-symmetrical men. The authors specify that the "preference for symmetry may be owing to a lack of an aversive odour rather than the presence of a pleasant odour".

Singh, D., & Bronstad, P. (2001). Female body odour is a potential cue to ovulation.

Proceedings: Biological Sciences, 268(1469), 797-801.

Singh and Bronstad in their article "Female body odour is a potential cue to ovulation" delves into the subject of whether human fertility is detectable. The authors believe that due to other findings and studies, ovulation may not be concealed, and to go even further, men might be able to smell when women are ovulating. The authors did a study with 17 regularly cycling women, and asked them to wear a plain white t-shirt to bed for two nights during ovulation and three nights during their luteal stage. The experiment was controlled for smell, so women were not allowed to eat certain potent foods, engage in sexual activity, or sleep with other people or pets, as well as other restrictions. Then the t-shirts were placed in freezer bags. 52 men who did not know the women in the study rated the smell of the t-shirts based on three values: sexiness, intensity, and pleasantness.

The authors believed that the men would rate the t-shirts of the highly fertile women as more attractive. The results showed that the ratings of sexiness and pleasantness had strong correlations to where a woman was in her menstrual cycle. Body odour was rated as more sexy and pleasant during the follicular phase. Then the authors had the same men rate the same t-shirts after another week of the t-shirts being in the freezer bag at room temperature. Passing of time made the t-shirts of the ovulating women smell even more attractive to the male raters. The authors note that this difference in smell may only occur when it is in a controlled experiment, as compared to an ancestral environment.

Durante, K., Li, N., and Haselton, M. (2008). Changes in Women's Choice of Dress

Across the Ovulatory Cycle: Naturalistic and Laboratory Task-Based

Evidence. Society for Personality and Social Psychology.

http://psp.sagepub.com/content/34/11/1451

This article discusses a study done by the authors about how women dress based on their ovulatory cycle. Human's ability to conceal ovulation may increase women's ability to mate, and not just with their partner. The study involved 88 female undergraduates at the University of Texas, all between 17 and 30 years of age. The girls came in for two sessions; one session when they were close to ovulation, and one when they were not. They were photographed at each session and asked to draw what outfit they would wear if they were to go to a social party with single, attractive people in attendance. The variables to determine if women would dress more revealingly during ovulation included if the woman was in a relationship, if she was happy in that relationship, if she was a virgin, her SOI, and her selfperceived attractiveness. The study found that sexually experienced women were more likely to dress more sexily close to ovulation than women who had not ever had sex. Single women and sexually unrestricted women were more likely to show more skin during ovulation. Women with higher self-perceived attractiveness showed more skin close to ovulation. Those happy in their relationships were more likely to show more skin closer to ovulation.

In general, women closer to ovulation were more likely to draw an outfit showing more skin, but did not dress significantly differently to the lab, likely because it was on campus and not at a party.

Gangestad, S., Simpson, J., Cousins, A., Garver-Apgar, C., & Christensen, P. (2004).

Women's preferences for male behavioral displays change across the menstrual cycle. *Psychological Science*, *15*(3), 203-207.

This article discusses how women react to men's behavioral and nonverbal displays during different times in the woman's reproductive cycle. The authors composed a study with 237 normally ovulating women and 76 men from the University of New Mexico and Texas A&M University, respectively. An attractive female was videotaped asking questions, and then the men would watch the video and give answers to the questions, which would also be videotaped. The men were under the impression that the woman was interviewing the man for a lunch date, and they were asked to tell the interviewer why they would be a good date. The 237 women in the study then watched the videos of the men and rated their attractiveness as a short-term mate and as a long-term mate. The researchers predicted that the women who were most fertile would be more likely to rate men as a good shortterm mate, rather than a long-term mate. The researchers also thought that with the non-fertile women, there wouldn't be much difference between choice of short-term (attractive for short-term affairs) versus long-term mates (attractive for a long-term relationship).

The authors figured out when all of the women would most likely ovulate, and they also figured out how attractive the males were as short-term and long-term mates. Their hypothesis that ovulating females would prefer good short-term mates over good long-term mates was correct; women at high fertility were more attracted to the good short-term mates.

Manning, J.T., Scutt, D., Whitehouse, G.H., Leinster, S.J., and Walton, J.M. (1996).

Aymmetry and the Menstrual Cycle in Women. *Ethnology and Sociobiology*,

17: 129-143. Elsevier.

Fluctuating Asymmetry (FA) in humans may be a sign of phenotypic quality, and therefore important in human mate choice. Body asymmetry is negatively correlated with number of lifetime sexual partners, and positively correlated with age at first copulation. Breast symmetry could be a reliable indicator of fertility. Soft-tissue traits can change in symmetry; breast size changes according to fertility.

The authors measured 5 traits in women and measured symmetry, then examined their uterus, ovaries, and adnexae to confirm when ovulation occurred.

Asymmetry is highest at the beginning and the end of a cycle with a peak mid-cycle.

Then they measured breast asymmetry using mammograms and figured out volume of breasts. Absolute asymmetry was the size of the left breast minus the size of the right breast. Asymmetries in breasts were much larger than asymmetries in non-sexually selected traits such as digits and ankles.

The results showed that there is a transitory increase in asymmetry followed by a marked reduction which indicates and coincides with ovulation.

#### OUTLINE

1. Introduction: While the commonly held belief is that estrus, or ovulation, in humans is hidden, there is actually a considerable amount of evidence to the contrary. Many studies have shown that normally cycling females change behaviorally and physically when they are more fertile. Thesis: ovulation is not hidden in humans; there are both physical and behavioral changes in ovulating females that can be detected.

# 2. Physical Changes:

- a. Female voices get higher at stages of high fertility, and therefore more attractive to males.
- b. Also, their body odor changes as they get closer to ovulation, and males rate fertile women's odors as more sexy and pleasant than nonfertile women's odors.
- c. Not only do their voices and odors become more attractive to the opposite sex, but also their faces become more attractive during the fertile phase of the menstrual cycle. Both males and females chose the fertile photo of the women's picture pairs more than 50% of the time.
- d. Last, at ovulation, there is an increase in cyclical asymmetry in women's breasts. High symmetry at mid-cycle shows that the woman is fertile, and males are more attracted to symmetry in women.
- e. Another physical sign of estrus is that lap dancers make more money in tips while they are ovulating than they do at other stages of their cycle, and normally-cycling dancers make more money at every stage

of the cycle than pill-using dancers make. Women at high fertility are somehow more attractive to males. (Make this possibly behavioral-maybe girls are acting more slutty or whatever and *that's* what gets them more tips)

# 3. **Behavioral Changes**:

- a. Women dress differently at different phases of their cycle. Both sexually experienced and non-experienced women are more likely to dress more revealingly closer to ovulation. Sexually experienced women are even more likely than non-experienced women to do so.
- b. Rate of sexual activity increases as fertility increases. Women at high fertility are more likely to initiate sexual activity, have stronger desire, and have more sexual fantasies.
- c. Furthermore, women who are in relationships but haven't had sex with their partner are more likely to have extra-pair desire. Women satisfied in their relationships reported less extra-pair desires, and women unsatisfied in their relationships reported more extra-pair desires at time of ovulation.
- d. Women rated men's t-shirts on pleasantness, sexiness, and intensity.

  The more symmetrical the man being rated was, the more attractive his smell would be to women at high fertility. Ovulating women find the odor of symmetrical men more attractive, while non-ovulating women don't have a preference between symmetric men and non-symmetric men.

- e. Another difference between how ovulating vs. non-ovulating women choose mates has to do with what women want while they are fertile versus what they want while they aren't fertile. Women who are close to ovulation prefer males with good short-term mate qualities.
- f. To bring this a step further, women who choose their mates while they are normally cycling choose men who are MHC dissimilar to themselves, while pill-using women choose men who have good long-term mate qualities. Relationships with women who are using birth control while they choose their mates have higher general satisfaction, but lower sexual satisfaction. They have lower separation rates and generally longer relationships. Relationships with women who picked their mates while normally cycling have higher sexual satisfaction, but lower general relationship satisfaction.
- 4. **Significance**: Why is all of this significant? Women change during high fertility for a reason: to attract a mate and therefore increase chances of getting pregnant. While males can have an unlimited amount of children because they are fertile almost 100% of the time, females only have a limited number of chances to get pregnant. This is why men can have so many more children then women can. When a woman has sex while she isn't ovulating, there is only a 3% chance of conception. Ovulation increases the chance of getting pregnant, and so this is when women feel the drive to have sex, even if they are unaware of this occurrence. The behavioral changes that ovulating women experience occur in order to shape how women choose their mates.

The physical changes women experience occur in order to make men see them as more attractive, and therefore the men are more willing to mate with them.

5. **Back to thesis/ conclusion**: Discuss how though human estrus signaling is not as strong as it is with, say, apes, it *can* be detected. We are largely unaware that we can detect estrus, but nonetheless we can. We (particularly men) are subtly influenced by the behavioral and physical changes that ovulating women go through, and react to these changes accordingly. The outward signs of ovulation in human females ensure that females mate when they are most fertile and therefore continue the population.

#### INTRODUCTION

Female chimpanzees display their period of peak fertility by a large, pink swelling of the genital skin. This swelling is so visible that a male chimpanzee can see a female's swelling from even a mile away. When human females are in their follicular, or fertile, phase, it is so much less obvious as their nearest relatives. <u>common chimpanzees, as to appear hidden or obscured</u>. However, contrary to the belief that ovulation is hidden in humans, there is emerging evidence hinting that fertility may be detectable in subtle ways. Several studies have investigated correlations between for example, peak fertility and changes in voice, body odor, facial attractiveness, sexual activity, and mate choice. Normally ovulating women need a system to ensure reproduction, and that system is non-concealed ovulation. Though males and females may not be fully aware or conscious that a woman is at her peak fertility, they actually do sense changes in the woman that make her more attractive to males, and therefore more likely to procreate. Estrus, or ovulation, is not *completely* hidden in humans; there are both physical and behavioral changes in ovulating females that *can* be detected.

#### **THEORY**

When a female chimpanzee or a female bonobo are ovulating, they display their fertility by a bright pink swelling of the sex skin. These "sexual swellings increase female attractiveness and stimulate male sexual arousal" (Deshner, 2004). Like with female humans, chimpanzees have a period of peak fertility, and males respond to this increased chance of conceiving. While chimpanzees are ovulating, they become more promiscuous and "generally mate with several mates during a swelling period" (Deshner, 2004). The obvious signal of female chimpanzees' fertility has a purpose: to obscure paternity, and therefore reduce the risk of male aggression against the infant. If a female chimpanzee is having sex with multiple males, the males won't know who the father of the resulting infant is. They will then be less likely to harm the infant, because it could be their infant. There is another reason for female chimpanzees to display their ovulation through sexual swellings:

Dominant males could thereby monopolize a female during the time when probability of fertility is highest, while less dominant males could still achieve copulations during periods of lower (but nonzero) probability of fertility. This enables females to balance the benefits of confusing paternity to reduce the risk of infanticide on the one hand and to bias paternity towards the dominant male to increase paternal care. (Deshner, 2004).

Evolution has worked in the favor of female chimpanzees and bonobos; because paternity is obscured, females can get more time and investment out of the males. The males give their time and energy in case the child is their own.

Though chimpanzees and bonobos both have sexual swellings during their period of fertility, there is a difference between the two. "The tumescent phase of the female's genitals, resulting in a pink swelling that signals willingness to mate, covers a much longer part of estrus in bonobos than in chimpanzees" (de Wall, 1995). Bonobos have a swelling before and after they ovulate, which encourages male interest and investment for a longer period of time. "Keeping swelling size... high after ovulation might increase her chances of mating with additional males" (Deshner, 2004). This can further confuse paternity as well as increase time and investment for longer. Between bonobos, chimpanzees, and humans, human females have the longest time and investment from males. Human females have sex during every stage of the menstrual cycle, as well as before puberty begins and after menopause. Males can't quite tell when females are fertile because they have sex throughout their lives.

In comparison to bonobos and chimpanzees, human females have nearly hidden ovulation. However, it isn't quite hidden; there *are* subtle cues. These cues could be due to intra-sexual selection theory, which means that women compete with other women during their peak fertility, and becoming more attractive gives them a "leg-up". There also may be sexual selection theory in play, where women become more attractive to the opposite sex during ovulation so that they have greater reproductive success. Non-concealed ovulation is likely due to a combination of both theories; women compete with other women for the best mate, and become more attractive in order to get a good mate. Though human females don't have a bright pink sexual swelling when they ovulate, they do have some

subtle signs of fertility. Men can use these signs to their advantage by paying attention to the subtle signs of ovulation in females; it is in their interest to know when women are fertile so that they do not have to use time, energy, or investment on females who aren't fertile.

# PHYSICAL CHANGES

The physical changes that occur as females transition in and out of fertility are not exaggerated, obvious ones. They are subtle and minor changes, and though each is small, all of them add up to one end result: a more sexually attractive female. One change that occurs as females get closer to ovulation has to do with vocal pitch. As women get closer to ovulation, their voices get more "feminine", and therefore more appealing to males. In a study by Bryant and Haselton, 69 normally cycling females from UCLA were tested to see if voice pitch does in fact get higher closer to ovulation. The authors reported that "for the spoken sentences only, high-fertility recordings were significantly higher in pitch than low-fertility recordings" (Bryant 2009). This is one way that evolution has ensured that a man will find a woman sexually attractive while she is fertile. Though a man may not know that his partner's voice is higher and more feminine during her fertile phase than it normally is, he will still likely be attracted to her during that time. If the situation were between strangers at a party or a bar, perhaps a man would gravitate toward a woman who is ovulating, because he subconsciously likes the sound of her extrafeminine voice.

Another reason a man could be more attracted to his partner while she is in her follicular phase is that she may smell more attractive. According to a study done by Singh and Bronstad, women smell differently depending on which stage of their menstrual cycle they are in. In this study, women were asked to wear new t-shirts to bed for two nights during ovulation, and for three nights during their luteal stage.

Then men rated the smell based on sexiness, pleasantness, and intensity. The men

rated "body odours associated with the ovulatory phase as more pleasant than odours associated with the non-fertile phase" (Singh 2001). The men also rated these t-shirts as more sexy. After a week, the t-shirts smelled even more sexy and pleasant to the male raters; however, the authors note that this occurred in a controlled experiment, and may be different than in a natural environment (Singh 2001). The fact that men can smell differences in ovulating women is just one more sign that ovulation is not as concealed in humans as previously believed.

Not only do ovulating women's voices and body odors become more attractive to the opposite sex, but also their faces become more attractive. In a study by Roberts et. al, researchers took pictures of 48 women; one picture was taken during the fertile stage of the woman's cycle, and the other photo was taken during the luteal phase. Each picture was shown with a "mask" (obscured hairstyle and condition) and without a mask. Male and female raters were asked to look at the photo sets and choose the picture that they found more attractive. Whether the woman in the photo set was masked or unmasked, 63 male and 61 female raters chose the photo of the woman in her fertile stage more often than they chose the woman in her luteal stage. These "results indicate that the perceived attractiveness of women's faces varies across the menstrual cycle and is higher in the periovulatory than in the luteal phase". The increase in estrogen during ovulation causes slight alterations in female's faces, producing stronger estrogenized, or "womanly", features. (Roberts 2004).

Another sign that estrus is in fact not hidden is that there is a fluctuation of symmetry in accordance with a woman's menstrual cycle. Some body parts, such as

fingers, toes, and ears, are not sexually selected, while other body parts, such as breasts, are sexually selected. When a woman is ovulating, her breasts actually change size in order to become more symmetrical. In "Asymmetry and the Menstrual Cycle in Women" by Manning et. al, the authors conduct a study in which they measured women's breasts when they were ovulating and when they weren't ovulating, and came up with a very interesting result. "Breast size... is strongly dependent on position in the menstrual cycle". At the beginning and end of a woman's cycle, her breasts are at their peak of asymmetry. During ovulation, however, they are at their peak symmetry. Other body parts can fluctuate in symmetry as well, but breasts were found to vary the most, because they are a sexually selected trait. (Manning 1996).

Why is it important for women's faces and breasts to be symmetrical? Simply, because "in general men will find symmetry more attractive than asymmetry" (Manning 1996). The more symmetrical a women is, the more attractive. Symmetry has been correlated with fertility, so if a woman becomes more symmetrical, she looks more fertile, and therefore more attractive. Being more symmetrical when she is most likely to conceive will help a woman find a mate. In fact, the more symmetrical a woman is, the more partners she will have in her lifetime. "Body asymmetry has been found to be negatively correlated with number of self-reported lifetime sexual partners and positively correlated with self-reported age at first copulation" (Manning 1996). Therefore, not only is a woman more likely to have more partners is she is symmetrical, but also she may lose her virginity at a younger age than other, less symmetrical females.

When women become more attractive when they are more fertile, it is more likely that a man will find them sexually attractive, and therefore conception is more likely. The change in women's appearance has an evolutionary task: to ensure reproduction. The point of this evolutionary tool making a woman more attractive is to give her a sort of "leg-up" in the dating market. So even if a woman's physical changes during her time of ovulation are small and seemingly insignificant, these changes actually have a high value when it comes to males choosing mates. Let's say there were an "attractiveness scale" of 1 to 10. If a woman is normally a "7" on this scale, but she becomes an "8" when she's ovulating, she will probably have more men to choose from, and so she can be more picky in her mate selection. This way, she can choose a mate who has good short-term mate qualities that indicate good genes. Good genes in a mate can lead to better genes for the offspring that will be the result of this mate selection. Therefore, a woman becoming more attractive when she is fertile can lead to better offspring with better genes.

One more physical sign that estrus is not hidden can also be interpreted as a behavioral sign of ovulation. In a famous study of strippers/ lap dancers, it was found that lap dancers make more tips when they are ovulating. "Ovulatory cycle effects of tip earnings by lap dancers: economic evidence for human estrus" by Miller, Tybur, and Jordan discusses how women who are ovulating make more money in tips than they normally do, and they also discuss how women who are not using birth control make more in tips at all stages of their cycles than women who are on hormonal birth control. In their study, the authors split the women's cycles into three phases: the menstrual, fertile, and luteal phases. The naturally cycling

dancers made the most money in tips while they were ovulating than in their menstrual or luteal phases. However, they also made more tips in their luteal phase than they did in their menstrual phase (when it is the least likely they will get pregnant). From this information, it makes sense that women who were using birth control always made less in tips; these women were always the least likely to get pregnant due to birth control. (Miller 2007).

It is possible that the dancers at high fertility were making more tips because they were more physically attractive at that time. They could have more symmetrical breasts and faces, a more feminine voice, a different odor, or any combination of the above. However, it is also possible that ovulating dancers are acting differently, and so earning more tips.

# BEHAVIORAL CHANGES

Miller et. al describe estrus as "a phase of increased female sexual receptivity, proceptivity, selectivity, and attractiveness" (Miller 2007). Attractiveness as a "side effect", so to speak, of estrus, is a physical sign that a woman is fertile. The other explanations are more behavioral. When a woman is ovulating, she is more receptive to males sexually (meaning she is more likely to have sex) and she is also more selective, because there is more at stake. If a woman has sex while she is in her luteal phase, it is not very likely that she will get pregnant from the copulation, so it does not matter as much if her partner has good traits or genes that could potentially be passed down to a child. However, when a woman is ovulating, it is much more likely that she will get pregnant from the copulation, so she will be more particular in her mate selection. This leads to certain behavioral changes when a woman is at her peak fertility.

The study about tip earnings during different phases of the menstrual cycle leads to the assumption that the dancers in their fertile phases are making more money in tips because they are more attractive than usual. However, it is also possible that these dancers are acting differently, and so they are making more tips. It is more possible that the combination of behaving differently and looking more attractive leads to better tips. One behavioral change that women go through when they are ovulating is that they dress in a less conservative way. This may not apply to the women lap dancing, however, because they don't wear a lot of clothing during the shifts to begin with. For the rest of the normally cycling females, though, ovulation causes a change in attire.

"Changes in Women's Choice of Dress Across the Ovulatory Cycle: Naturalistic and Laboratory Task-Based Evidence" by Durante et. al shows how women who are in the fertile stage of their cycles will likely display more skin than when they are not ovulating. In this study, students from the University of Texas had two sessions, one during their luteal phase and one during their fertile phase. In both sessions, they were photographed and also asked to draw what outfit they would wear if they were to go to a party that night. In general, women closer to ovulation would often draw an outfit showing more skin than the outfit they drew when they were not ovulating. The photographs of the women didn't turn up any significant results, but that could be because the women were at the University of Texas campus and attending classes, not going to a social event where there would be available mates. When women are ovulating, they subconsciously want to attract a mate who can impregnate them, and a college campus is probably not the place where that is going to occur. However, if an ovulating female is going out to a party that night, *that* is when her attire comes into play. (Durante 2008).

There are a couple different reasons why women reveal more skin when they are more fertile. The obvious reason is that women are trying to attract mates.

Another "possibility is that women simply feel more attractive near ovulation and they put more effort into their appearance as a result". It is also possible "that women dress up more near ovulation as a result of an increase in intrasexual competitiveness" (Durante 2008). So women could be dressing up for themselves, for men, or for other women. Perhaps women wear more revealing clothing when they are fertile because they want to compete with other women in order to get a

better male mate. No matter why this phenomenon occurs, the study revealed that women who were at high fertility compared to low fertility definitely sketched outfits that were more revealing and sexy. Also, "this difference was stronger for women who were closest to ovulation during their high-fertility session" (Durante 2008). So, as women get more fertile and more close to ovulation, they are even more likely to dress in a sexy and revealing fashion.

Besides dressing differently at times of high fertility, women also become more sexually active. Sexual activity includes both sex with a partner or masturbation. Bullivant et. al's "Women's sexual experience during the menstrual cycle" is a two part study in which the authors first tested women to see when they were the most fertile, and then asked them detailed personal questions about their sexual activity. The authors studied data from 46 women, looking at sexual activity, sexual desire, sexual fantasies, loneliness, and partnership status. When asking about sexual activity, "participants also indicated who initiated the activity". The authors used urine samples and Basal Body Temperature results to find out when there was a preovulatory surge of Luteinizing Hormone, which signals fertility. (Bullivant 2004).

The results supported the authors' hypothesis that as fertility increased, sexual activity and desire would increase. The "rate of sexual activity showed a clear pattern relative to the onset of the preovulatory LH surge". As a woman's follicular phase came closer and nearer to ovulation, her rate of sexual activity increased. "Sexual activity was highest during the follicular phase and lowest during the first 3 days of menstruation" (Bullivant 2004). There is more than one reason why sexual

activity is lowest during the first three days of menstruation, however. At this time, pregnancy is unlikely and so there is less biological incentive to have sex, but it is also possible that the presence of blood may deter the desire for sexual activity for either the male or the female.

Another issue could arise from whether a woman is in a relationship or not; women in a relationship probably have more access to sexual activity than single women. The authors controlled for this issue, and determined that "a peak in sexual motivation surrounding the LH surge was detected in women with and without regular sexual partners, demonstrating that it is also robust across different social conditions". Because sexual activity is defined as both sex with a partner and masturbation, this pattern of sexual activity increase close to ovulation can be applied to women having sex and women not having sex. Overall, the authors concluded that close to ovulation, "women were more likely to initiate sexual activity, had stronger sexual desires... and had more sexual fantasies" than when they were in other phases of their menstrual cycles (Bullivant 2004). Becoming more sexually active when a woman is most likely to conceive is an evolutionary tool used to ensure the continuation of the population.

Bullivant et. al's study focused on sexual activity and desire within females, unrelated to whether they were in a relationship or not. "Ovulatory shifts in female sexual desire" by Pillsworth, Haselton, and Buss studied sexual desire as well, but they wished to know how this relates to relationships. The authors hypothesized that women get more sexually desirous when they are more likely to conceive and that mated women will feel the effects of this more strongly. Also, they hypothesized

that women who are mated and not happy with their mates are more likely to desire extra-pair copulations (desiring sex with someone who is not their partner) as they get more fertile. (Pillsworth 2004).

This study of 173 women unveiled interesting results. The women who were in relationships but hadn't had sex with their partner were more likely to report extra-pair desires at time of ovulation. This could be because these women have, at that point in time, zero probability of conception with their partner, because they haven't had sex. The women who are having sex with their partners, however, do have a chance of conception, and so they are less likely to seek other men to conceive with them. However, "higher levels of extra-pair desires near midcycle were observed for longer relationships". Women in relationships are less likely to desire other men while they are ovulating, *unless* the women have been in their relationships for a long time. Perhaps women subconsciously feel that if conception hasn't happened yet, it may not happen with their current partner, and so when they become more fertile, they feel that they need to seek a different mate. Also, women who were not satisfied in their relationships were more likely to have extrapair desires during high fertility. Overall, "among women currently in romantic relationships, those with high conception probability reported significantly more composite sexual desire than those with low conception probability". (Pillsworth 2004).

Another behavioral change that occurs when women are most likely to conceive is that women become attracted to a certain type of man. When women are ovulating, they become more symmetrical to become more attractive, because men

find symmetry attractive in women. However, women also find symmetry attractive in men. Normally, this symmetry does not matter as much, but when a woman is at her peak fertility "women may tend to prefer sexual relations with men who have particular attributes". In a study by Gangestad and Thornhill, women rated men's body odor. The men were measured for symmetry and the women reported where they were in their menstrual cycles. The men wore clean, new t-shirts for two nights and then the women smelled the t-shirts and rated them based on sexiness. intensity, and pleasantness. The authors found that the more symmetrical the man was, the more attractive his smell was to women who were at high fertility. Women at low fertility didn't have a preference for symmetrical or asymmetrical men. Also, women who were using hormonal birth control had no preference or significant correlation. Just like how symmetrical females experience greater mating success, so do symmetrical males. Females who are ovulating prefer symmetrical males, because this is a good genetic quality that could be passed on to offspring. When females are not ovulating, they do not care as much if their mate is symmetrical, because it is less likely that they will conceive. But during high fertility, women are more particular about who they are mating with. (Gangestad 1998).

Besides desiring symmetrical men, women at high fertility also want men who act a certain way. In another research study by Gangestad, "Women's preferences for male behavioral displays change across the menstrual cycle", 237 women watched videos of 76 men. The men were under the impression that they were being interviewed for a lunch date, and they had to tell the interviewer why they would be a good date. The researchers hypothesized that the fertile women

would prefer the good short-term mates, rather than good long-term mates. Gangestad et. al also believed that for the non-fertile women, there wouldn't be much difference between choice of short-term versus long-term mates. Short-term mates are attractive for short-term affairs, and long-term mates are attractive for a long-term relationship. Women who are ovulating are more attracted to men who display good genetics and who are sexually attractive, because these women are more likely to get pregnant and so want good traits to pass onto their offspring. The authors' hypothesis that ovulating females would prefer good short-term mates was correct; "women's attraction to these displays in a short-term mating context... increased on high-fertility days". Also, the women rated the men in the videos as more attractive when the women were more likely to conceive. (Gangestad 2004).

When ovulating women choose mates that are good for the short term, the resulting relationship is quite different than when women who are using birth control choose a mate. Women who are at their peak of fertility want a man who will pass on good genes to the child they might conceive, and a man who is attractive, manly, and sexy; basically, somebody who is attractive for a one-time affair. When a woman is not ovulating and is looking for a long-term relationship, she looks for different qualities, such as a man who is financially stable, has the same general moral values, is kind, is good looking, and is a good prospect for a husband.

Therefore, when women end up with the man they chose while they were ovulating, they may be sexually satisfied but unsatisfied in other aspects of the relationship. In "Relationship satisfaction and outcome in women who meet their partner while using oral contraception", Roberts et. al study 2519 women, both birth control using

and non-using. The authors asked the women if they were on birth control when they chose their partner (or ex-partner), and then asked detailed questions about the general and sexual satisfaction of that relationship. The authors thought that "hormonal contraceptive users might make different actual partner choices than they otherwise would". (Roberts 2011).

Ovulating women will choose a mate who is MHC-dissimilar to themselves, because when a couple is MHC-dissimilar their offspring will have better immunity. However, non-ovulating women or women on the pill who are not likely to get pregnant are not searching for a short-term mate, and so they might choose a mate who is MHC similar. Also, women who are ovulating at time of mate choice choose men who are more sexually compatible. Roberts et. al's results showed that "women who used OC (oral contraceptives) during partner choice... scored lower on sexual arousal with their partner" as well as scoring lower on satisfaction with his sexual adventurousness, attraction towards him, and sexual proceptivity. Women who were not using OC scored higher on sexual arousal and sexual satisfaction with their partner. However, women who were using OC during mate choice report higher general satisfaction and financial provision satisfaction. (Roberts 2011).

Some of the women's relationships had ended at the time of the study, and they reported who ended the relationship and whether the relationship had began with birth control or not. In general, OC users had a lower separation rate and generally longer relationships. Though the separation rate is lower for OC users, OC users were also more likely to end the relationship than their partner. Though

general relationship satisfaction is higher if women chose their partner while on birth control, this may not be enough to sustain a relationship.

# CONCLUSION

Where a woman is in her menstrual cycle can determine the man she ends up with. It can also determine how long the relationship lasts, and the level of satisfaction with general and sexual aspects of the relationship. Ovulation can also cause women to pick more symmetrical men and it can cause women to dress more revealingly. Women even want to have sex more often when they are ovulating. Why does all of this happen? If women had concealed ovulation, men wouldn't subconsciously know when women were most likely to get pregnant. Human females do not have concealed ovulation; there are many signs when a woman is at peak fertility. While males can have almost an unlimited amount of children in their lifetime because they are always fertile, women are not always fertile and so have a limited amount of offspring. When a woman has sex while she isn't ovulating, there isn't much of a chance of getting pregnant. Though women aren't generally aware of it, when they ovulate they have a higher sex drive and become more attractive in order to increase the likelihood of conception. The behavioral changes that ovulating women experience occur in order to shape how women choose their mates, and the physical changes are to ensure that men see them as sexually attractive.

Though all of these physical and behavioral changes are not obvious, they are not concealed either. Both women and men are subtly influenced by the changes that ovulation women go through, and men react to these changes accordingly.

These outward signs of high fertility in females ensure that females will copulate when fertile and therefore continue the population. While human females don't

have quite as obvious a sign of ovulation as chimpanzees and bonobos do with their bright genital swelling, human ovulation can be detected.

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