OPINION

Do women have a hidden heat period?

Juan J. Tarín1 and Vanessa Gómez-Piquer

Department of Functional Biology and Physical Anthropology, Faculty of Biological Sciences, University of Valencia, Burjassot, Valencia, Spain

1To whom correspondence should be addressed at: Department of Paediatrics, Obstetrics and Gynaecology, Faculty of Medicine, University of Valencia, Avda, Blasco Ibañez 17, Valencia 46010, Spain. E-mail: tarinjj@uv.es

This article aims to throw light on the controversial topic of whether women have a ‘heat’ period within their menstrual cycle. The majority of publications in this field report, in addition to a periovulatory peak, no changes at all or even rises in male- and female-initiated sexual activity, woman’s sexual desire, autosexual activity and sexual arousability, and interpersonal sexual activities during the mid-follicular and late luteal phases. The lack of a distinct pattern of women’s sexual behaviour across the menstrual cycle may be explained by the interplay between cyclical endocrine fluctuations and many psychological, social, cultural and environmental factors, as well as the methodological shortcomings associated with menstrual cycle research. However, studies focused on cycling changes in women’s olfactory and visual perception show that, in comparison with women at other phases of the menstrual cycle, women at mid-cycle exhibit increased sexual motivation that biases recognition performance towards objects with a sexual meaning, evaluate the unattractive sweat substance androstenone as more pleasant, and display enhanced preference for the odour and face shape of masculinized, physically attractive and symmetric men. On the other hand, men find the scent of women at mid-cycle more pleasant and sexually attractive than during the luteal phase.

Key words: estrus/estrous cycle/heat period/menstrual cycle/sexual desire

Females of most vertebrate species exhibit recurring periods of heightened sexual activity in which they are sexually attractive, proceptive and receptive to males. In mammalian females (except Old World monkeys, apes and humans), this periodic sex appeal is referred to as ‘heat’ or ‘estrus’. The term estrus comes from the Greek word ‘oistros’ (gadfly). Estrus literally means ‘in a frenzied state’, due to the fact that when gadflies buzz around cattle they drive them into a frenzy of hyperactive behaviour similar to that exhibited by females at estrus (Sanders and Bancroft, 1982; Thornton and Finn, 1998). The term estrus, however, is also used to designate the ovulatory cycle (estrous cycle) and to refer to a specific stage of the cycle when ovulation occurs (estrus phase). Moreover, the estrus stage of the cycle is not when behavioural estrus occurs since females from most mammalian species allow the male to mate only at the proestrus stage of the ovarian cycle (Lisk, 1978; Thornton and Finn, 1998). Due to the multiple usage of the word estrus, in this article we will use the term ‘heat’ to designate the restricted stage of the ovarian cycle at which the female’s sexual demands are made evident to conspecific males and mating takes place. As mentioned above, the term estrus is not used to refer to the reproductive cycle of Old World monkeys, apes and humans. In this particular group of primates (suborder Anthropoidea, infraorder Catarrhini), the ovarian cycle is called a menstrual cycle because of the periodic physiological haemorrhage that occurs at ~30 day intervals (Michael et al., 1976). Notwithstanding, with regard to ovulation and hormonal levels, the mid-cycle in a catarrhine menstrual cycle is comparable with the estrus stage of the ovarian cycle in the majority of mammals as presented in a review (Nelson, 1995). In contrast to the majority of mammalian species, women do not exhibit an evident and manifest heat period, extending sexual activity to all parts of the ovulatory or menstrual cycle. This condition has prompted many researchers to propose that this reproductive trait is ‘lost’ or absent in women as a consequence of the trend from prosimians to humans in cortical expansion and concomitant control over physiological factors (Steklis and Whiteman, 1989). However, this hypothesis is not supported by data suggesting that the interplay among various physiological and environmental factors in vertebrate reproductive behaviour is not scaled according to the degree of encephalization or conscious control, but varies according to the particular ecological and social demands that each species faces (Steklis and Whiteman, 1989). In this article, we aim to throw light on the controversial topic of whether women have
a heat period within their menstrual cycle. To reach this goal, we will first describe the pattern of sexual behaviour in women. Thereafter, we will focus on extant evidence supporting the notion that women exhibit recurring mid-cycle periods of enhanced sexual desire, although not so patent and overt as those displayed by females from other mammalian species.

Pattern of women’s sexual behaviour

To describe the pattern of women’s sexual behaviour, we can borrow an instructive paradigm from studies of Old World monkeys and apes. In these primates, as in other mammalian species, female sexual behaviour can be separated into three components: attractiveness, proceptivity and receptivity (Michael et al., 1976; Herbert, 1978; Nelson, 1995). Attractiveness is defined as the value the female has as a sexual stimulus for the male. Although attractiveness can be subdivided into behavioural and a non-behavioural components, it is usually limited to non-behavioural traits to avoid misunderstandings with the concept of proceptivity (see below). Examples of non-behavioural traits are the estrogen-induced formation of a mixture of vaginal aliphatic acids that apparently functions as a stimulating ‘pheromone’ in rhesus monkeys, and the estrogen-induced development of large oedematous swellings of the sexual skin covering the perineum in female chimpanzees, baboons, mangabeys and talapoins. Proceptivity is defined as the behavioural gestures used by a female to induce the male to attempt to mount her. In rhesus monkeys, for instance, females perform ‘head bobs’, ‘head ducks’, ‘hand reaches’ and genitalia presentations to males by backing their hindquarters into the male. Finally, receptivity is defined as the willingness of the female to accept the male’s attempts to mount her (Michael et al., 1976; Baum et al., 1977; Herbert, 1978; Hill, 1988; Nelson, 1995).

Like the majority of mammals (Takahashi, 1990; review), most group-living Old World monkeys and apes copulate most frequently around ovulation and least frequently during the luteal phase, although there may also be a secondary peak just before menstruation, such as occurs in rhesus monkeys (Michael et al., 1976; Baum et al., 1977; Herbert, 1978; Nieuwenhuijsen et al., 1986; Hill, 1988). These cyclical fluctuations in sexual interaction are due basically to an estrogen-induced increase and a progesterone-induced decrease in female’s attractiveness at mid-cycle and the luteal phase respectively. The increased premenstrual sexual interaction reported in rhesus monkeys may be the result of vanishing levels of progesterone and increased concentrations of testosterone that occur just before menstruation (Baum et al., 1977).

Proceptive behaviour is also modified by hormone fluctuations during the menstrual cycle although these changes are less prominent than those associated with the female’s attractiveness. In most studies, maximal female proceptivity is observed at mid-cycle, coincident with increasing androgen secretion from the ovaries near ovulation. Receptivity is still less hormone-sensitive than proceptivity. In fact, although there is evidence showing that estrogen stimulation is very important in receptivity, female primates can allow copulation at all stages of their ovarian cycle, particularly in laboratory settings. We should note that the ability of female primates to copulate at any time does not mean continuous female interest (Herbert, 1978; Hill, 1988; Wallen, 1990; Nelson, 1995). A notable exception to this rule would be marmosets, which have clearly defined estrous cycles, with mating behaviour limited to the estrus stage. Furthermore, with the exceptions of chimpanzees and rhesus monkeys that exhibit a highly stereotyped mating posture, gorillas, orangutans and bonobos (Pan paniscus), like humans, do not tend to show a stereotyped female copulatory pattern (Nelson, 1995).

Literature shows that sexual interaction in non-human primates depends not only on endocrine fluctuations during the cycle but also on individual preferences, physiological status, environmental conditions and many social factors including the composition of groups, social structure, number of previous copulations with a particular male, kinship, dominance rank, age, pair compatibility and the phase relationship between the cycle of different females (Herbert, 1978; Rogel, 1978; Sanders and Bancroft, 1982; Nieuwenhuijsen et al., 1986; Takahashi, 1990; Wallen, 1990; Nelson, 1995).

Human sexual behaviour is far more subject to cognitive and social influences when compared with other non-human primates. McNeill, for instance, cites up to 15 psychosocial factors that may potentially affect women’s sexuality, including development of sexual self-image in childhood, age of sexual debut and sexual history, current sexual self-image, lifespan of current relationship, relationship satisfaction, contraceptive use, pregnancy motivation, past history of terminations, parity, cycle-related change in emotional and physical well-being, health status and stress levels, personality type (introvert or extrovert, etc.), past history and current risk of sexual violence, menstrual taboo observance, and ethnic and religious orientation (McNeill, 1994). Each one of these factors, acting either separately or together, may conceal or inhibit any effect of endocrine fluctuations during the menstrual cycle on women’s sexual behaviour. Furthermore, the existence of a hormonal influence on women’s sexuality may be overridden or obscured by several methodological difficulties associated with menstrual cycle research, such as: (i) the generalized trend to rely on small numbers of women and cycles; (ii) the use of varying and sometime inaccurate methods for determining cycle phases, different aspects of sexuality, diverse groups of women, inappropriate control groups, retrospective versus prospective data collection procedures, women’s awareness versus unawareness of the aim of self-report studies (Englander-Golden, et al., 1980) and subjective versus physiological or objective measures of sexual arousal (Sanders and Bancroft, 1982; Hedricks, 1994; Regan, 1996; Van Goozen et al., 1997); and (iii) the possible existence of a conditioning or learning mechanism that might facilitate response to sexual stimulation if women are previously tested during the follicular phase (Slob et al., 1996), or an association between the baseline levels of a particular measure and the response due to a stimulus (Meeuwenisse and Over, 1993).

Taking into account the great importance in women’s sexuality of psychological, social and cultural factors as well as the methodological shortcomings associated with menstrual cycle research, it should not be surprising that the majority of

2244
Do women have a hidden heat period?

Changes in women’s olfactory and visual perception across the menstrual cycle

Proceptivity

The literature provides hints suggesting that during the periovulatory phase, women show an increased sexual motivation that biases recognition performance towards objects with a sexual meaning. In particular, when visual stimuli such as nonsense syllables, sexual stimuli, pictures of babies and stimuli related to body care are randomly presented to women at different phases of their menstrual cycle, women at their periovulatory phase (tested after the occurrence of a distinct increase in urinary concentration of LH) display an enhanced number of correctly (pictures of nude men) and falsely (mainly pictures of women occupied with body care) recognized sex stimuli when compared with women tested during the mid-luteal phase (4–10 days before menses) (Krug et al., 1994). More recently, Krug et al. have shown that women at their periovulatory phase (tested also after the occurrence of a distinct increase in urinary concentration of LH) exhibit a higher event-related brain potential, specifically, a higher late positive component (average potential 500–700 ms post-stimulus. This electroencephalogram parameter is an indicator of stimulus processing taking place after stimulus selection for working memory) after watching pictures of nude men (sex stimuli) than after watching pictures of babies (stimuli eliciting maternal attitudes), women occupied with body care (stimuli of body care) and ordinary people (neutral control stimuli) (Krug et al., 2000). In contrast, during menses (day 2–5 of the menstrual cycle) and luteal phase (4–9 days before menses), this relationship is not apparent. In addition, when women were asked to rate the subjective emotional value of the pictures as positive, neutral or negative, sex stimuli were rated less often as negative during the periovulatory phase than during menses and the luteal phase.

These results disagree with a previous study by Johnston and Wang which observed an increase in late positivity to sexual stimuli during the luteal phase (after day 21 of the test cycle) compared with the ovulatory phase (days 11–18 of the test cycle) (Johnston and Wang, 1991). We have to note, however, that Johnston and Wang did not determine the ovulatory phase using an ovulation test kit designed to detect urinary LH. Instead, they counted 14 days backward from the first day of the menses following the testing day and, therefore, results from both studies are not comparable.

Further evidence suggesting that women experience enhanced sexual motivation around the time of ovulation comes from the study by Penton-Voak et al. reporting that Japanese female university undergraduate students judge men’s faces that are more masculinized as physically more attractive.
when asked during the follicular phase (between the end of menses and ovulation, which was assumed to occur 14 days before the onset of menses) than during the luteal phase (after the day of putative ovulation and before the onset of menses) (Penton-Voak et al., 1999). Likewise, for a short-term relationship, British undergraduate women, when asked during the follicular phase rather than during the luteal phase, preferred face shapes that were more masculine. In contrast, no cyclic changes in face shape preference were detected when women judged male face attractiveness for a long-term relationship or when using oral contraception (Penton-Voak et al., 1999).

Data from the previous study have been recently endorsed by Penton-Voak and Perrett using a self-selected, non-undergraduate population of women who responded to a questionnaire published in a British Broadcasting Corporation magazine (Penton-Voak and Perrett, 2000). In particular, Penton-Voak and Perrett found that non-pill-using female respondents in the follicular phase (days 6–14 since the onset of the last menses) of their menstrual cycle were more likely to choose a masculine face when presented with feminized, average or masculinized male faces than those in the menses and the luteal phase. This outcome has been further reinforced by Johnston et al. who reported that female undergraduate volunteers exhibit a shift toward a more masculine male face preference during the high-risk phase (defined as the 9 days prior to ovulation, which was estimated to occur 14 days prior to the onset of menses either following or taking place between the experimental sessions) of the menstrual cycle (Johnston et al., 2001). Furthermore, Johnston et al. evidenced no menstrual shift in other facial preferences, including attractive female, dominant male, dominant female, etc. Such a result rejects the hypothesis that the observed effect of menstrual cycle on women’s preferences toward male faces is due to a general change in mood over the menstrual cycle.

Taking into account the enhanced female preference at midcycle for masculinized faces, it is not surprising that non-pill-using women prefer darker photographs of male faces during the first two-thirds of the menstrual cycle when compared with the last third (Frost, 1994). Skin colour is sexually dimorphic within all races, with men having browner and ruddier complexions than women as result of differing melanin and haemoglobin levels in the skin’s outer layers. Therefore, a preference for darker photographs of male faces around ovulation could be considered a preference for exaggeration of a male trait (Penton-Voak and Perrett, 2000).

Periodic changes in women’s preferences across the menstrual cycle are not restricted only to visual signals, but also to odour stimuli. Within this context, the studies by Hummel et al. and Grammer are worth noting (Hummel et al., 1991; Grammer, 1993), in which normally ovulating women evaluated androstenone, a human unattractive sweat substance with putative pheromone-like characteristics and with higher production in males, as more pleasant near ovulation [days 6–14 of the menstrual cycle counted from the first day of the last menstruation (Grammer, 1993) or the day before and the day of ovulation evaluated by a gynaecologist (Hummel et al., 1991)] when compared with either menses or days 15–28 of the menstrual cycle (Grammer, 1993) or any other time of the menstrual cycle (Hummel et al., 1991).

Gangestad and Thornhill have shown that normally cycling, i.e. non-pill-using, women tend to prefer the odour of men with low fluctuating asymmetry [fluctuating asymmetry is a marker of developmental imprecision or instability, i.e. decreased individual’s ability to cope with genetic and environmental perturbations during development (Gangestad and Thornhill, 1998)]. It is evidenced by absolute deviation from perfect symmetry on characters that are, on average, symmetrical on the two sides of the body (Gangestad and Thornhill, 1998; Rikowski and Grammer, 1999) near the fertility peak of their menstrual cycle (days 6–14 counted from the first day of the last menstruation), whereas normally ovulating women during their low fertility stages (all days of the menstrual cycle except days 6–14) and women using a contraceptive pill, show no significant preference for either symmetrical or asymmetrical men’s odour. Thornhill and Gangestad have recently replicated these findings using a larger sample and statistically controlling for certain potential confounds, such as men’s hygiene practices (Thornhill and Gangestad, 1999).

In addition, Thornhill and Gangestad showed that women’s preference for the scent of facially attractive men is greatest during their period of peak fertility (estimated as the average of two sets of values obtained following a forward and a backward method).

The studies by Gangestad and Thornhill (Gangestad and Thornhill, 1998; Thornhill and Gangestad 1999) are not the only reports showing cyclical changes in women’s odour preference associated with men’s physical traits. Rikowski and Grammer have also observed that women in the most fertile phase of their menstrual cycle (days 5–16 counted from the first day of the last menstruation) tend to prefer the odour of facially attractive and symmetric men (Rikowski and Grammer, 1999). We should note that low fluctuating asymmetry is associated with higher facial attractiveness, men’s number of sexual partners, frequency of their partner’s orgasms and number of extra-pair copulation partners (Gangestad and Thornhill, 1998). Interestingly, British women’s extra-pair copulation rates are significantly higher during days 6–14 of the menstrual cycle (counted from the first day of the last menstruation after standardization to a cycle of 28 days) when compared with days 15–28 (Bellis and Baker, 1990).

**Receptivity**

Little is known about the occurrence of cyclical changes in receptive behaviour in women exposed to male olfactory or visual signals. Benton observed that depending on the phase of the menstrual cycle, the mood of women was affected by daily smelling of androstenone (Benton, 1982), a putative human pheromone that induces positive attitudes towards males and whose oxidation results in the unpleasant androstenone (Grammer, 1993). In particular, Benton showed that the application of androstenol to the upper lip of women each morning for a month, beginning on the first day of the onset of menstruation, resulted in them rating their moods at the middle of their menstrual cycle as submissive rather than aggressive (Benton, 1982). This result apparently disagrees with a recent
study by Graham et al. reporting that during the periovulatory phase (not later than 2 days after a positive ovulation kit result), women in response to both film and fantasy stimuli exhibited a trend for greater genital response or arousability (measured using a vaginal photometric device) when exposed to a control fragrance compared with both a male and a female fragrance (Graham et al., 2000). In contrast, during the early follicular phase (not later than 2 days after the last day of menses), only the male fragrance was associated with increased genital response in women aroused during sexual fantasy. However, the study by Graham et al. should not be considered in the present discussion because of the puzzling results obtained (we should take into account that the control fragrance was just sterilized water) as well as the unknown composition of the male and female fragrances (Graham et al., 2000).

**Women’s olfactory and visual cues across the menstrual cycle**

**Attractiveness**

In contrast to periovulatory females of some Old World monkeys and apes which display swellings of the sexual skin covering the perineum (Baum et al., 1977; Herbert, 1978; Hill, 1988; Nelson, 1995), periovulatory women, in common with female vervet monkeys, gibbons and orangutans, do not show any obvious body change marking a period of increased sexual desire (Steklis and Whiteman, 1989). At the most, they only display subtle changes in skin colour towards a lighter complexion (van den Berghe and Frost, 1986) and in dimension and symmetry of traits made up wholly or in part of soft tissue, such as ear size, digit length and breast size (Scutt and Manning, 1996; Manning et al., 1996). However, these periovulatory changes are too slight to be easily detected even by a pair-bonded male familiar with the female’s skin colour and the aforementioned soft-tissue traits.

On the other hand, in contrast to that which occurs in rhesus monkeys (Rogel, 1978), the regulatory influence on women’s sexual behaviour by vaginal aliphatic acids is highly question-able and remains to be demonstrated. There are several lines of evidence supporting this notion. Firstly, only a small proportion of women exhibit a peak production of vaginal aliphatic acids at mid-cycle (Huggins and Preti, 1976; Michael et al., 1976), and others even show a peak during the luteal phase (Huggins and Preti, 1976; Sokolov et al., 1976). Secondly, although it has been reported that vaginal secretions from pre-ovulatory and ovulatory women have a less unpleasant odour than those from menstrual, early luteal and late luteal phases, the odour of vaginal secretions is not particularly attractive to humans, at least in an in-vitro test situation (Doty et al., 1975). Thirdly, Morris and Udry could not observe any effect on marital sexual behaviour or male desire of a synthetic hypothetical human female pheromone containing the same mixture of short-chain aliphatic acids found in human vaginal secretions (Morrison and Udry, 1978). Likewise, neither total aliphatic acid contents nor relative concentrations of particular acids seem to provide signals for male chimpanzees (Pan troglodytes, species closely related to humans) to discriminate between adult females in the follicular or the luteal phase (Fox, 1982). Finally, men under normal circumstances do not exhibit the prominent behavioural feature of investigating and sniffing the anogenital area of women such as occurs in Old World monkeys and apes (Michael and Zumpe, 1982).

It has been also reported that men’s attractiveness ratings of women’s body scent are unrelated to women’s probability of conception (estimated as the average of two sets of values obtained following a forward and a backward method) (Thornhill and Gangestad, 1999). However, these investigators used a between-subjects design (follicular and luteal body odours were collected from different women), which may have prevented the detection of weak yet reliable odour cues. Recent studies using a within-subjects design (follicular and luteal body odours were collected from the same women) have found that men rate women’s bodily odours as more pleasant and sexually attractive around ovulation than during the other phases of the menstrual cycle. For instance, Singh and Bronstad reported that men judge the scent of T-shirts of normally cycling women, i.e. non-pill-using women displaying regular menstrual cycles, worn during their ovulatory phase (days 13, 14 and 15 of the menstrual cycle, being day 0 the day of onset of menstrual blood flow or blood spotting), as more pleasant and sexually attractive than the scent from T-shirts worn during the luteal phase (days 20, 21 and 22) of the menstrual cycle (Singh and Bronstad, 2001). Likewise, Poran found that men who are pair bonded with a woman, judge her body odours (collected from saliva, vagina, inner labia major, underarms and loin) from her ovulatory phase (predicted with the aid of an ovulation predictor kit) as more pleasant and longer lasting than body odours collected about 1–2 days after cessation of menstrual flow, 1–2 days prior to ovulation, 1–2 days post-ovulation and about a weak prior to the predicted next menses (Poran, 1994).

In conclusion, although previous the literature shows that women do not exhibit a distinct pattern of sexual behaviour across the menstrual cycle, recent evidence based on women’s olfactory and visual perception and men’s olfactory perception suggests that women experience recurring periods of increased attractiveness and proceptivity at the periovulatory stage of their menstrual cycle. However, the changes in women’s attractiveness and proceptivity across the menstrual cycle are not as obvious, patent and overt as those displayed by females from other mammalian species.

**Acknowledgements**

This work was supported by grants FIS 00/0668 and FIS 01/0138 from Instituto de Salud Carlos III, Fondo de Investigación Sanitaria, Ministerio de Sanidad y Consumo.

**References**


