Ovulatory cycle effects and hormonal influences on women's mating psychology

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Abstract

Do hormones affect women's mating psychology? In which way? Why? In this chapter, we address these questions and summarize the current evidence on associations between women's ovulatory cycle, hormonal changes and their mating psychology. We focus on potential changes in sexual motivation, mate preferences and attraction to potential mates. We further evaluate potential changes in cues to fertility, whether they are detectable by others, and whether these changes lead to corresponding affective and behavioral changes in romantic partners. We also discuss potential implications of research on hormonal contraception on mating and point out potential reasons why some findings do not replicate.

Human estrus

Most mammalian females experience reproductive cycles (also known as ovulatory cycles), varying in typical length from species to species. In human females, alongside some other primates like chimpanzees and many simians, these cycles are marked by shedding and vaginal ejection of the uterine lining as menstrual bleedings, which is why these cycles are called menstrual cycles in these species. Menstrual cycles are usually characterized by two different phases: the follicular phase begins with menstrual bleeding and ends with ovulation, which then introduces the start of the second phase, the luteal phase. Conception is only possible in the fertile period of each cycle, in human females up to six days, usually the day of

ovulation and the five days prior. The different cycle phases are characterized by substantial hormonal changes, especially in the reproductive hormones estradiol and progesterone: Whereas estradiol levels are usually higher in the follicular phase and peak around the day of ovulation (with a second, smaller peak mid-luteal), progesterone levels are lower in the follicular phase and rise in the luteal phase, peaking around mid-luteal.

Females of many non-human mammals only actively engage in sex (proceptivity) and accept male advances for sex (receptivity) when conception is possible (i.e, when they are fertile), and signal their fertility by changes in appearance and behavior towards males. This phenomenon of mammalian reproductive biology is widely known as estrus or heat, and is defined as a "relatively brief period of proceptivity, receptivity, and attractivity in female mammals that usually, but not invariably, coincides with their brief period of fertility" (Symons, 1979, p.97). The question whether human females also experience estrus has long been discussed. Women experience extended sexuality, which means that they do not only engage in sexual behavior when fertile, but also at other times across the cycle or post-menopausal. Further, women do not show obvious changes in appearance or behaviors across their cycle. These facts led to the assumption that (classically defined) estrus was lost in human females, possibly due to the evolution of pair bonding, to ensure paternal investment in their offspring and reduce infanticide (Alexander & Noonan, 1979; Rooker & Gavrilets, 2020; Symons, 1979). However, the lost estrus claim has been challenged by findings suggesting that there are, indeed, psychological and behavioral changes across the ovulatory cycle. Although these changes seem not to be as obvious as estrus changes in some non-human mammals, they suggest that estrus was not lost in humans, despite the evolution of extended sexuality (Thornhill & Gangestad, 2008). Nevertheless, women do not show classically defined estrus in that they are only sexually active during a restricted fertile period. Changes in appearance or women's mating psychology across the cycle, in line with human

female estrus, might be rather subtle and probably predominantly characterized by changes in the nature of women's sexual interests.

Ovulatory cycle effects on women's mating psychology

In which way do women's sexual interests change across the cycle? There are different hypotheses about potential changes in line with human estrus and multiple studies investigated these. Here, we review the most prominent ones and discuss the current state of evidence.

The Good Genes Ovulatory Shift Hypothesis (GGOSH)

Probably the most prominent hypothesis in this research area is the *Good Genes Ovulatory Shift Hypothesis* (GGOSH). It predicts that women's mate preferences, so with whom they aim to mate, change across the cycle to increase genetic benefits for their offspring. More precisely, this hypothesis makes three directly testable predictions (Gangestad et al., 2005; Gildersleeve et al., 2014): First, when fertile, women should be more sexually attracted to male characteristics that indicate genetic quality, compared to their low-fertility days. Second, cycle shifts in women's mate preferences for genetic quality indicators should be absent or only weakly present when evaluating men for long-term relationships (i.e. not only their sexual attractiveness). Third, when fertile, women should not be more sexually attracted to men's characteristics that reflect a higher suitability as a long-term partner. Pillsworth and Haselton (2006) expanded these ideas and hypothesized that women may have evolved a dual-mating strategy in which they secure investment through their (long-term) bonding partner, while obtaining good genes for their offspring through extra-pair copulations with other men when fertile. These extra-pair copulations when fertile might especially happen when their partner lacks in displaying indicators of genetic quality. But how can women know which man possesses good genes? Indicators of genetic quality are hypothesized to be characteristics that signal superior immune functioning or are costly to produce and maintain,

as only highly fit individuals in good phenotypic condition can afford to invest resources in these traits. Indirectly such characteristics should thus be indicative of low mutation load, compatible genes, and genes well fitted to the current environment, i.e. "good genes" (Gangestad et al., 2015, Gildersleeve et al., 2014). Characteristics that have been assumed to reflect good genes in men were higher testosterone levels, dominant behavior, physical attractiveness, symmetry, and masculinity. Importantly though, some purported indicators of good genes are controversial, because reported findings challenge the hypothesis that they actually signal heritable fitness benefits and immunocompetence (e.g. Nowak et al., 2018; Scott et al, 2012, 2014).

There is a large number of studies reporting supportive evidence for the GGOSH. When fertile, women report to prefer short-term sexual relationships with men who have more masculine or symmetrical faces (Penton-Voak et al., 1999; Penton-Voak & Perrett, 2000), masculine or muscular bodies (Little et al., 2007), masculine (deeper) voices (Feinberg et al., 2006; Puts, 2005, 2006), masculine scent (Gangestad & Thornhill, 1998; Havlíček et al., 2005), and men who show more dominant behaviors (Gangestad et al., 2004, 2007). Further, changes in the target of women's sexual desire have been reported. In a study by Gangestad and colleagues (2002), women reported more sexual fantasies with men other than their primary partners when fertile. Women's increase in extra-pair desire in the fertile phase seems to be especially pronounced when they perceive their partner less sexual attractive, interpreted as a lack of genetic quality (Haselton & Gangestad, 2006), and has been linked to higher estradiol levels (Grebe et al., 2016). In contrast, sexual desire for women's primary partner might be higher when progesterone levels are higher, which usually marks the non-fertile, luteal phase (Grebe et al., 2016). To capture the idea that women's conceptive vs. non-conceptive sexual interests may not be identical, Thornhill and Gangestad (2008) proposed the concept of *dual sexuality*. While sexual behavior outside the fertile phase may have

evolved for pair-bonding purposes to secure long-term investment and protection from primary partners, the most obvious benefit for sexual behavior within the fertile phase is conception, which might be most adaptive to secure from different, genetically fitter partners. Hence, sexual interests should vary across the cycle accordingly.

While the evidence for the GGOSH has long been perceived as being convincing, doubts arose around 2014, when two meta-analyses focusing on shifting mate preferences across the cycle were published and came to strikingly divergent conclusions about the existence of these effects (Gildersleeve et al., 2014; Wood et al., 2014). As a consequence, a number of different researchers collected new data to investigate the robustness of changes in women's mate preferences and sexual desire across the cycle. In most of these newer studies, previously reported evidence in line with the GGOSH did not replicate. More precisely, recent studies based on more extensive data and more rigorous methods than earlier ones reported fertile-phase increases in both extra-pair and in-pair sexual desire (Arslan et al., in press), and positive association of estradiol and negative of progesterone with general sexual desire (Jones et al., 2018a; Roney & Simmons, 2016) rather than specific shifts in extra-pair desire. Further, no compelling evidence was found for hormonal associations or ovulatory cycle shifts in mate preferences for men's faces (Dixson et al., 2018; Jones et al., 2018b; Marcinkowska et al., 2018), bodies (Jünger et al., 2018a; Marcinkowska et al., 2018; van Stein et al., 2019), voices (Jünger et al., 2018b), and behaviors (Stern et al., 2020). In contrast, other recent studies reported some evidence in line with the GGOSH, as changes in estradiol and progesterone were not associated with general sexual desire, but with changes in short-term mating orientation (Shirazi et al., 2019), or extra-pair desire when fertile (Grebe et al., 2016). Further, a reanalysis of Jünger and colleagues (2018a, a study reporting null results) argued to find evidence for changes in mate preferences for men's bodies (Gangestad et al., 2019). However, the latter has been criticized because of analytical decisions and challenged

again by a multiverse analysis showing no robust evidence for cycle shifts in preferences for men's bodies with the same data (Higham, 2019; Jones et al., 2019b; Roney, 2019; Stern et al., 2019). Meanwhile, an even larger study did not replicate evidence in favor of the GGOSH, as reported in the reanalysis (Stern et al., 2021). Overall, recent non-replications call into question all different lines of previous evidence in supportive of the GGOSH and make it unlikely that previously reported effects are robust (Jones et al., 2019a), or at least, challenge the GGOSH as it is currently formulated (Stern et al., 2021). The controversy seems to be ongoing, but on balance very convincing new evidence in support of the GGOSH would be necessary to still regard it a plausible explanation of cycle shifts in women's mating psychology. Meanwhile alternative hypotheses have been developed.

Motivational Priority Shifts

Based on life history theory, the *Motivational Priority Shifts Hypothesis* (MPSH, Roney, 2018, for more details see also Roney, this volumne) suggests that women's motivations might change across the cycle to reflect varying costs and benefits of behaviors across cycle phases. When women can conceive, their mating motivation (e.g. general sexual interest) has a greater priority because the probability of conception provides a fitness benefit that outweighs potential costs of sex. Other motivations (e.g. somatic motivation to forage and eat) receive less priority in the fertile phase, but increase during cycle phases when women cannot conceive (e.g. the luteal phase). Motivational priority shifts should mainly be regulated by fluctuating ovarian hormones, especially estradiol and progesterone. Other, non-hormonal effects (e.g. relationship status) might also have effects on shifting motivations, potentially independent of hormonal effects. A number of recent studies provided evidence in line with this hypothesis: In a diary study with naturally cycling women, Roney and Simmons (2017) collected daily hormone samples and self-reported food intake (how much participants ate during each meal) across one cycle. In line with lower motivations to forage and eat when

fertile, participants reported a drop in food intake on the days approaching ovulation. Shifts in food intake were positively predicted by progesterone and negatively by estradiol levels. Further, for the same sample of participants, Roney and Simmons (2013, 2016) reported an increase in general sexual desire when fertile, with positive effects of estradiol and negative of progesterone. More evidence for an increase in either general sexual desire or both in-pair and extra-pair desire when fertile (Arslan et al., in press; Jones et al., 2018a) further support this hypothesis. While not necessarily assuming shifting mate preferences across the cycle, shifts in mate attraction, with all men being evaluated as a little more attractive when fertile, have been interpreted as being in line with the MPSH (Jünger et al., 2018a, 2018b; Stern et al., 2020). However, in a newer study Stern and colleagues (2021) replicate shifts in mate attraction, but also report them to be very weak. Moreover, previous studies reporting mate preference shifts, or shifts specifically in extra-pair sexual desire, may not be in line with the MPSH.

Between-cycle or between-women effects

Rather than shifting within-cycles, women's mate preferences or attraction might either shift between-cycles within the same woman. Cycles with higher estradiol levels might be on average "more fertile" with a higher probability of conception (Roney & Simmons, 2013). Thus, women might experience shifts in preferences or attraction in cycles with higher estradiol levels. This hypothesis would predict preference or attraction shifts associated with specifically estradiol levels across cycles (Lukaszewski & Roney, 2009). However, evidence for links between estradiol and shifts in mate preferences is mixed, as reviewed by Roney (this volumne), and in fact most studies did not directly assess hormone levels.

Rather than between-cycles within the same woman, mate preferences and attraction, as well as sexual desire, might vary between-women, potentially due to inter-individual differences in hormone levels. In line with this assumption, the perceptual spandrel hypothesis has been

proposed. This hypothesis states that variability in women's attractiveness and their mate preferences might not have been developed as an adaption, but rather are a by-product of between-women differences in hormone levels (Havlíček et al., 2015). Women with higher estradiol levels should possess a higher mate value, because they are generally evaluated as more attractive than women with lower estradiol levels. Thus, due to mate value-contigent preferences (Penke et al., 2007), and as more attractive women express higher standards for hypothesized indicators of good genes (Buss & Shackleford, 2008), they should also prefer more attractive men as partners. Whereas evidence for this hypothesis is scarce, some studies suggest that, indeed, changes in women's mating psychology may occur due to between-women, not within-women, hormonal effects. Rather than estradiol, progesterone levels, interacting with women's relationship status, were reported to predict between-women differences in mate preferences for masculine faces (DeBruine et al., 2019; Marcinkowska et al., 2018b). This interaction effect was not replicated for preferences of men's bodies (Stern et al., 2021). Independent of differences in hormone levels, a large study with 2,160 twins and their siblings suggests that different mate preferences for masculine faces are rather due to genetic variation than to contextual factors, such as fluctuations across the cycle, providing more evidence for between-subjects effects (Zietsch et al., 2015).

Other hormonal influences on women's mating psychology

Other hormones beyond estradiol and progesterone, especially testosterone and cortisol, have been discussed to influence women's mating psychology, particularly sexual desire and sociosexual orientation (interest in uncommitted sex). However, published studies seem to agree on no compelling evidence for within-woman changes in sexual desire, sociosexual orientation, mate attraction, or preferences that are associated with fluctuating testosterone or cortisol levels (Jones et al., 2018a, 2018b; Jünger et al., 2018a, 2018b; Marcinkowska et al., 2019; Roney & Simmons, 2013; Shirazi et al., 2019). Regarding between-women effects, it

seems that testosterone is linked to individual differences in women's mating psychology. More precisely, partnered women seem to have lower testosterone levels than singles (Edelstein et al., 2011, van Anders & Goldey, 2010) and polyamorous women are reported to have higher testosterone levels than monogamous women (van Anders et al., 2007). Furthermore, testosterone has been reported to be positively associated with sociosexual orientation, general sexual desire, and solitary sexual desire (e.g. masturbation), but negatively to dyadic sexual desire (e.g. sex with a partner, Shirazi et al., 2019; van Anders, 2012). However, neither testosterone nor cortisol seem to be related to inter-individual differences in mate preferences (Marcinkowska et al., 2019).

Moderating variables

One potential reason for mixed findings regarding mate preferences and attraction might be that there a large individual differences in how women react to fluctuating hormones across the cycle (Jones et al., 2019a). Thus, differences in mate preferences or attraction might also be influenced by other variables than women's cycle or fluctuating levels of estradiol and progesterone. Across different hypotheses, one variable that is assumed to potentially affect mate preferences and attraction, is women's relationship status. Women's mating psychology might be sensitive to the presence of a stable investing long-term partner, as benefits of pregnancy might only outweight its costs when a supportive mate is available to provide care and resources. Thus, changes in mate preferences in line with the GGOSH, or changes in mate attraction according to the MPSH might be stronger for or even -exclusive to women in relationships. Indeed, a number of studies suggest that relationship status is an important variable, in that mate attraction shifts or shifts in sexual desire only occur for women in relationships (Jünger et al., 2018a, 2018b; Pillsworth et al., 2004). Mate preference shifts have either been reported to be stronger either for women in relationships (Penton-Voak et al., 1999) or for singles (Gangestad et al., 2019). However, relationship status did not influence

mate attraction (Stern et al., 2021) or mate preferences (Jones et al., 2018a; 2018b; Jünger et al., 2018a, 2018b; Marcinkowska 2018a; Stern et al., 2020, 2021) in the vast majority of studies. Mixed findings might be explained by the fact that effects of relationship status could be more complex than assumed, as relationships differ strongly (e.g. in satisfaction, commitment, length, exclusiveness and many other factors). Thus, relationship status might not result in the same effect for every woman. Individual differences in effects of relationship status and the exact factors that are accountable for these differences should be examined in future research.

Other variables that have recently been discussed to potentially influence cycle shifts are stress, mood, and premenstrual symptoms (PMS). Stress has been reported to affect reproductive hormones, in that high levels of stress inhibit estradiol levels (Roney & Simmons, 2015), and decrease preferences for masculine faces (Ditzen et al., 2017) as well as attraction to male bodies (Jünger et al., 2018a). However, the latter has not been replicated in a recent, larger study (Stern et al., 2021). Higher perceived stress also seems to be related to lower dyadic sexual desire (Raisanen et al., 2018). Mood has been reported to be related to in-pair, but not extra-pair sexual desire (Shimoda et al., 2018), whereas it does not seem to be significantly related to ovarian hormones (Schwartz et al., 2012). Further, Kiesner and colleagues (2020) argue that PMS symptoms, such as cramps or depression, might strongly influence mate selection and should, thus, be investigated as covariates in studies focusing on cycle related changes in women's mating psychology. However, research on how these variables affect changes in mate attraction or preference is overall scarce.

Cues to fertility

Besides changes in women's sexual interests being a potential cue for men to infer whether they are currently fertile or not, it has been assumed that there might be other, more appearance-related cues to women's fertility. Human females do not display obvious cues to

fertility that would be comparable to sexual swellings in chimpanzees and bonobos, our closest primate relatives. However, it is possible that women may show more subtle changes to attract potential mates when fertile, consciously or not. Indeed, numerous studies suggest that women's attractiveness changes across the cycle. The first attempts to examine such potential cues to fertility focused on changes in women's scent and reported that body odor around ovulation is perceived as being more attractive than at other phases of the cycle (e.g. Singh & Bronstad, 2001). This finding has been successfully replicated several times (Gildersleeve et al., 2012; Havlíček et al., 2006; Kuukasjärvi et al., 2004; Thornhill et al., 2003). However, between-women differences might be larger than within-woman differences, and cyclical changes in attractiveness might be too small to be detectable by others (see also Roney, this volumne). Other studies have also reported that women's facial or vocal attractiveness changes across the cycle, with women being evaluated as more attractive around ovulation (Pipitone & Gallup, 2008; Roberts et al., 2004), which has also been linked to fluctuating levels in estradiol and progesterone (Puts et al., 2013). Whereas replication studies investigating voice attractiveness across the cycle are sparse, changing facial attractiveness has not been replicated in most subsequent studies (e.g. Bleske-Rechek et al., 2011; Catena et al., 2019; Jones et al., 2018c), casting doubt on earlier reports.

If women's attractiveness really changes across the cycle, what are the cues that change? Previously assumed fluctuating facial cues of fertility were facial shape and skin color (Bobst & Lobmaier, 2012; Burriss et al., 2015; Oberzaucher et al., 2012). However, changes in facial shape do not seem to replicate (Marcinkowska & Holzleitner, 2020) and changes in facial color are apparently too subtle to be detectable by the human visual system (Burriss et al., 2015). Voice pitch (how deep a voice sounds) develops under hormonal influences (Puts et al., 2013), and might thus change across the cycle. Evidence for this claim has been mixed so far, with some studies reporting higher female voice pitch around ovulation (Bryant &

Haselton, 2009), no differences in pitch between the fertile and the luteal phase (Banai, 2017) or even lower voice pitch when fertile (Karthikeyan & Locke, 2015). Thus, whether and how women's voice pitch changes across the cycle appears controversial.

Other research suggests cues to fertility that are more actively affected by women's behavior, including changes in clothing style (in that women dress more sexy, provocative or attractive) and in time spent grooming. Both can signal sexual interest and attract potential mates. After a first study reported that women try to look more attractive at peak fertility (Haselton et al., 2007), more studies followed reporting that women do or aim to wear more sexy, skin revealing clothes (Durante et al., 2008; Saad & Stenstrom, 2012; Schwarz & Hassebrauck, 2008), or prefer to buy sexier clothes (Durante et al., 2011). The latter has also been linked to fluctuating hormone levels (Blake et al., 2017a). Further, diary studies suggest that women spend more time grooming when fertile (Röder et al., 2009; Saad & Stenstrom, 2012). The prominent finding that fertile women wear more red or pink clothes (Beall & Tracy, 2013; Eisenbruch et al., 2015; Tracy & Beall, 2014), a color that is potentially worn to enhance attractiveness (Prokop & Hromada, 2013, but see Peperkoorn et al., 2016), failed to replicate in multiple recent studies (Arslan et al., in press; Blake et al., 2017b; Hone & McCullough, 2020). Summarizing the current evidence, it seems that women's grooming and choice of dress in terms of sexiness might change across the cycle, whereas clothing color does probably not. However, so far there is a lack of large scale replication studies investigating the robustness of these effects.

Male mate retention

If women's sexual interest changes throughout the cycle and there are, indeed, cues to fertility, do their partners recognize any changes? How do they react if their partner is more interested in mating with other men? Indeed, some research suggests a fertile phase increase in men's jealousy, but also in their affection to their partner, effects that predispose mate

retention behavior (Gangestad et al., 2002; Haselton & Gangestad, 2006; Pillsworth & Haselton, 2006). These behaviors have previously been interpreted as counteradaptions to shifts in women's mate preferences and sexual desire in line with the GGOSH. Arslan and colleagues (in press) did not detect changes in male mate retention, but note limitations of their study design to examine potential shifts. While it seems plausible that, should women's sexual interest show noticable changes, their close relationship partner shows a reaction, men's perspective and behavioral changes corresponding to female cycle shifts are overall understudied so far.

Hormonal contraception

If women's mating psychology is affected by changing hormone levels across the cycle, these effects are likely suppressed when taking hormonal contraception (e.g. the pill; Fleischman et al., 2010). Women taking hormonal contraception do not experience a fertile phase or ovulation and hormone levels are somewhat constant (Alvergne & Lummaa, 2010). Thus, women taking hormonal contraception should not experience changes in their mating psychology across the cycle. In line with this idea, it has been reported that women using hormonal contraceptives do not experience mid-cycle increases in sexual desire (Arslan et al., in press). Studies also reported overall weaker preferences for masculine men when women used oral contraceptives (Feinberg et al., 2008; Little et al., 2002). However, these findings were, again, challenged by failed replications, some of which even reported results in the opposite direction (Cobey et al., 2015; Jones et al., 2018b). Further, it has also been proposed that not only mate preferences, but also mate choice might be affected by hormonal contraceptives, in that women taking the pill might form relationships with other men than they would have chosen when not on the pill (Alvergne & Lummaa, 2010). As a consequence, relationship satisfaction, especially sexual satisfaction, as well as jealousy, might change when women switch from oral contraceptive use to none or vice versa after relationship

formation. This is known as the pill congruency hypothesis (Cobey et al., 2013; Roberts et al., 2014). Its rationale is that the hormonal pill might affect women's mate preferences in a way that they form a relationship with a partner who does not reflect their preferences after switching to non-hormonal contraception, thus causing a mismatch between preferences and the partner. However, a replication study with a substantially larger sample size than the original studies did not find support for the pill congruency hypothesis (Jern et al., 2018).

Most of the mentioned studies relied on between-subject designs, which are confounded by potential selection effects, thus, differences between women taking the pill and non-pill users, which could interact with the investigated variables. To draw reliable inferences on how the pill affects women's mating psychology (as well as other outcomes), researchers should ideally employ either within-subject designs (assessing the same women while taking the pill vs. while naturally cycling) or blind randomized control trials (with some women randomly assigned to take the pill vs. other women to take a placebo, Alvergne & Lummaa, 2010). Since such studies are difficult to conduct, it is mandatory that appropriate statistical techniques are carefully applied in order to correct for confounding selection effects.

Methodological criticism and potential reasons for non-replicability

Many of the originally reported findings we review in this chapter failed to replicate in later studies, causing uncertainty whether these effects actually exist. How is it possible that different studies find different results regarding the same research question? There is no single reason for non-replicability, but several problems that might collude. First, many studies in this area are underpowered, which means that they did not investigate enough participants and/or assessments within participants to draw reliable conclusions. Underpowered studies can cause false negative (e.g. failure to detect an effect that exists), but also false positive (e.g. support for an effect that does not exist) results. For example, Jones and colleagues (2019a) conclude that the mean sample size of studies reporting mate preference cycle shifts for men's

faces before 2018 was only 40 participants, although an independent power analysis suggests that these studies (with their specific methods) would have required 900-1,000 participants to reliably detect a medium sized effect (Gangestad et al., 2016). Second, most of the studies before 2018 have used between-subjects designs, but their results have been interpreted as within-subject effects. As mentioned above, it is possible that mate preferences do, indeed, vary between-women rather than within-woman. Thus, between-subject designs are potentially confounded. Furthermore, between-subjects studies need an even larger sample size than within-subjects studies to have appropriate test power for cycle shifts (Gangestad et al., 2016). Third, most studies relied on measures to estimate the fertile window with suboptimal validity: Self-report data and counting methods to define the fertile days instead of validating their estimates with luteinizing hormone urine tests to pinpoint the day of ovulation, with the defined number of fertile days ranging widely from three to 20 days. Ovarian hormones were not directly assessed in most studies. However even if they were, hormone assays are increasingly under scrutiny regarding their own validity problems (Schultheiss et al., 2019). Fourth, variation in methods across studies can cause non-replicability, e.g. for stimulus presentation, using natural vs. artificial stimuli, different items, or sampling designs. Direct replications are rare. Fifth, researcher degrees of freedom and analytical flexibility, the fact that all researchers have to choose how exactly to conduct their study, formulate their hypotheses, analyze their data, and report their results, from a wide range of reasonable and defensible options (Wicherts et al., 2016), as well as publication bias in favor of positive findings attenuates replicability. Importantly, most of these issues are not exclusive to ovulatory cycle research, but are widespread across most scientific fields.

So which studies can we rely on? All studies come with limitations, and no single study should be regarded the final word on any research question. Robust effects should replicate across different methodological approaches and analytic decisions (Stern et al., 2019).

However, identical analytic decisions should also lead to similar results across different, comparable datasets (Stern et al., 2021). Every new dataset contributes valuable new information and should be used to re-evaluate the overall picture. This is especially true for well-powered replication studies, be it direct or conceptual replications. It is crucial to note that ovulatory cycle effects occur within subjects and are thus best studied using within-subject data, as between-subject studies require samples more than an order of magnitude larger to yield comparable power (Gangestad et al., 2016). It should also be noted that a lot of the older studies in this literature, which were more likely to report significant effects and larger effect sizes (as initial studies on a topic often do, the so-called winner's curse, Young et al., 2008), had critically low power (Jones et al., 2019a) and should thus be weighted accordingly. High power, coming from both more subjects and more assessments per cycle within subjects, are especially important when testing higher-order interaction effects (which are often predicted in this literature) since interactions are especially prone to yield false-positive results (Rohrer & Arslan, 2020). Studies in this literature also vary widely with regards to research transparency, including preregistration (or ideally registered reports), open data, scripts and materials, and supplementary robustness analyses. Given that there have been considerable analytic developments in this area (e.g. multilevel modelling and regarding the estimation of fertility) and that this literature has already sparked debates over the analysis of individual open datasets, making more of the data in this area open for re-evaluation would greatly benefit the field. Finally, more data is always helpful, especially on effects that have seen few replications so far, like the luteal shifts in eating behavior predicted by the MPSH.

Summary

Hormones, including flucutations across the ovulatory cycle, seem to have some impact on women's mating psychology, but probably less so or differently than previously assumed. The recent years saw a lot of methodological developments, failed large-scale replications, debates

over studies that allowed for it via their transparency, and the emergence of new alternative hypotheses. Though it is too early to call which hypothesis explains hormonal influences on women's mating psychology best, some findings seem to be more robust than others, e.g. that sexual desire and women's odor vary across the cycle. These rather robust findings suggest that estrus is not completely lost, but is also not overtly advertised in human females. Future studies should also investigate whether there are potential individual differences among women in the degree in which they show ovulatory shifts in their mating psychology, or whether some women show such shifts whereas others do not. Overall, more research is needed to clarify how exactly women's hormones and ovulatory cycles affect their mating psychology.

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