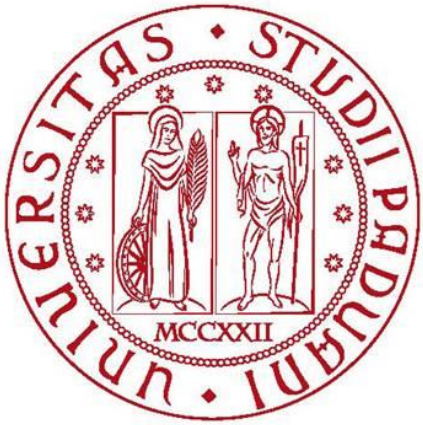


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# *Predictors of female sexual desire: testing the putative effects of negative mood and the menstrual cycle using mixed models analyses.*

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## Chapter 1: What is Sexual Desire?

Attempts to define and describe sexual desire can be tracked back to as recently as 1905, when Sigmund Freud introduced the term "libido". The concept of libido refers to a psychological energy that drives psychosexual development through different stages, and it's not until the "genital stage" that this energy gets translated into sexual urges. Later in the 60's Master and Johnson (1966), for the first time, defined the human's sex-response cycle as composed by arousal; plateau; orgasm and resolution, dropping the concept of libido without replacing it with anything else. Masters and Johnson were focused on observing physiological changes at different stages of the human's sexual response, not the psychological forces (i.e., desires) behind those observable sexual responses. However, given that sexual desire can be considered to be a cognitive/affective state which potentially anticipates sexual activity while not being directly associated with any physiological markers, it was not included in their theories.

The first definition that focused on "sexual desire" as a unique part of the human sex-response cycle, and not as an energetic force guiding human development, was provided by Kaplan (1977). Kaplan's conceptualization of sexual desire as an additional phase of human sexual response originates from her clinical work with patients complaining of low libido, which according to the author was also the most challenging sexual dysfunction to treat. Specifically, what would be considered" hypoactive sexual desire" was conceptualized as a loss of sexual appetite. In fact, Kaplan describes sexual desire as an appetite that is born in the brain. This appetite can either be inhibited or exploited, thus preventing or promoting sexual arousal and activity (Kaplan, 1977). However, since most of Kaplan's clinical work aimed at understanding and treating low sexual desire, we still lack an explanation of when and how sexual desire comes into play in case of a normal, healthy sexual functioning.

Nonetheless, once the relevance of sexual desire was recognized, researchers and clinicians began to search for a more thorough definition of this concept focusing on either the biological (Stanislaw & Rice, 1988) or clinical aspects (Levine, 2002; Kaplan, 1977; Basson, 2001), or attempting to define and measure sexual desire as a multi-dimensional construct (Spector, Carey & Steinberg, 1996). Possibly because of its recent history, we still lack a commonly accepted definition of sexual desire (see Meana, 2010 for a complete discussion). In addition, data collected from subjective measures (which still to date represent the only way to investigate sexual desire, since no physiological marker associated to sexual desire has been identified) suggest an additional concern related to the study of female sexual desire: women are not good at distinguishing between sexual desire and sexual arousal (Graham, Sanders, Milhausen & McBride, 2004). For this reason, it's not uncommon to find that terms such as "sexual arousal" or "subjective sexual arousal" are employed as synonyms of sexual desire creating confusion both to the reader, who cannot understand whether there's a difference or not between the two terms, but also to the research writer in the process of selecting terms that would be clear to the audience.

Another layer of confusion derives from the yet unsolved skepticism around the idea of *spontaneous* vs *responsive* sexual desire. According to some, spontaneous and responsive sexual desire should be recognized as two separate parts of the sexual response (Levin, 2005), while others sustain that spontaneous sexual desire does not actually exist, because desire always arises *in response to* either internal or external stimuli (Laan & Both, 2008). To better understand how the idea of responsive sexual desire was born, we have to go back to the beginning of the new century, when Basson (2000) overturned the idea of sexual desire as the initial force driving sex. Like for Kaplan, Basson's assumptions come from clinical observations and interviews with women complaining of low sexual desire. However, in this new frame, low sexual desire is not considered to be pathological: on the contrary, Basson

claims that women – especially those involved in a long-term relationship – do not experience those sexual urges typically found in men, or even in women at the first stage of a new romantic relationship. Rather, women mostly seek sex for other, non-sexual reasons, like the need of intimacy and emotional closeness to the partner. Therefore, women complaining of an absence of spontaneous sexual desire but still presenting *responsive* sexual desire, would not be classified as suffering of any sexual dysfunction. Thus, responsive sexual desire is understood as sexual desire in *response* to sexual cues that would be expected to elicit some sort of sexual response as, for example, a partner that takes the initiative. According to Basson, sexual desire might also come later than sexual arousal: if a woman on a state of "sexual neutrality" is willing to have sex with the partner, she can first become genitally aroused and later, because of a desire for intimacy, experiencing that sexual desire needed to continue sexual intercourse (Basson, 2002). Following Basson's new conceptualization of sexual desire as being responsive, some studies claimed that there is no such a thing as spontaneous sexual desire and that an increase in sexual desire always occurs in response to either internal or external stimuli (Laan & Both, 2008).

Despite the merit of not excessively pathologizing women who experience low sexual desire, which may feel "broken" just because they don't feel a spontaneous drive to have sex, or at least not as much as their partner does, Basson did not consider an important piece of sexual desire in the proposed model - solitary sexual desire. Solitary sexual desire refers to the desire of masturbation and experiencing sexual pleasure on one's own. Because sexual pleasure is not only about having sex with a partner, sexual desire cannot be considered to be exclusively about dyadic sexual desire (Spector et al., 1996). Nonetheless, this type of distinction between dyadic and solitary sexual desire is neglected by most measures (DeRogatis, Clayton, Goldstein, Lewis-D'Agostino, Wunderlich, & Cotton, 2011; Hendrick, Hendrick & Reich, 2006; Rosen, et al., 2000), so that when sexual desire is assessed through

these questionnaires, clinicians and/or researchers are actually exclusively measuring dyadic sexual desire. It's important to note that this problem is present even when using the criteria for a diagnosis of HSDD in the DSM-5 (American Psychiatric Association, 2013).

**How to measure Sexual Desire**

Probably because of a lack of consensus on its definition, sexual desire has been measured in different ways across studies, ranging from questionnaires designed to investigate different nuances of sexual desire (for example, Spector et al., 1996) to single dichotomous questions asking whether participants did or did not experience sexual desire (Laursen, Overvad, Olesen, Delmar & Arendt-Nielsen, 2006; Stanislaw & Rice, 1998). In addition, attempts have been made to measure sexual desire indirectly using sexual intercourse as a proxy for desire - for example, some researchers have tested for an association between the menstrual cycle and frequency of sexual behavior (see Harvey, 1987, for an example). Although it seems intuitive that measuring frequency of sexual intercourse would be an easier and a more objective measure than asking about level of sexual desire, there are three main reasons to why frequency of sexual intercourse is not a good index for sexual desire.

First, women don't always have sex simply because they feel the desire to have sex (Meston & Buss, 2007). Thus, an increased sexual desire is a preferable but not necessary condition to have sex among women (Basson, 2000). In fact, feeling in love, showing affection, increasing communication are all additional reasons mentioned by women when they were asked to select motivators for engaging in sexual intercourse. However, we cannot conclude that other factors that increase sexual desire, like being in love or searching for intimacy, act directly on sexual behavior (i.e., searching for, or being receptive to, sexual stimuli) rather than increasing sexual desire first. That is to say, it's not clear whether sexual desire should be considered as a mediating factor in the relationship between need for

intimacy and sexual behavior, or whether these alternative motivators to have sex should be treated as explanatory variables of frequency of sexual intercourse regardless of their effects on desire. Nevertheless, we need to control for such factors and include them in a coherent model when investigating changes in sexual desire and in sexual intercourse. It's important to underline that, it's not only unlikely that sexual desire isn't the only factor driving women's sexual behavior in general, but that multiple factors can drive the same woman's sexual behavior in different occasions. Therefore, asking about frequency of sexual intercourse cannot be considered a substitute of asking about sexual desire nor between different women, or within the same woman.

A second reason why frequency of sexual intercourse is not a good index for sexual desire is that frequency of sexual intercourse depends on having an available partner. This is true even for animals, but in their case the connection between estrus and sexual behavior it's easily made thanks to 1) a constrained period of availability for sex/reproduction, and 2) a less selective process of partner selection. Contrarily to animals, human sexual relationships are not limited to a specific period of time (i.e., ovulation) and they are usually not occasional, while they tend to be repeated within the same partners. It's therefore crucial to control for availability of a sexual partner, and not simply one's relationship status, when selecting the participants to include in a study investigating sexual desire. Let's consider the following cases. Woman A doesn't have a stable sexual partner, and thus she might not always have the possibility to decide when to have sex. Rather, her frequency of sexual intercourse would depend on when she finds an available partner. Woman B instead does have a stable partner, but they are in a long-distance relationship - thus, they don't live together, and they don't have the possibility to see each other on a daily basis. Frequency of sex for woman B is therefore constrained to the possibility of meeting her partner in person (note the "weekend effect" found in Roney and Simmons, 2013). Thus, it follows that studies

on human sexuality should evaluate not only relationship status of the participants included in the sample, but also partner's availability and actual frequency of sexual intercourse. In addition to actual sexual frequency, *desired sexual frequency* could also be addressed (i.e. *how many times would you like to have intercourse in a week?*). Therefore, including a set of measures of actual and desired frequency of sexual intercourse, together with partner availability, would provide a useful indicator of sexual preferences, thus, a complementary measure specific to dyadic sexual desire.

A third reason why frequency of sexual intercourse is not a good index for sexual desire concerns the possibility that a non-fulfilled desire for sex would not simply vanish but may accumulate with time. Although to date there is no study showing an increased sexual desire consequent to sexual abstinence (i.e., lack of sexual intercourse), several studies on human sexuality have controlled for recent sexual frequency (Beck & Bozman, 1995) for the selection of the sample. Such a choice suggests that there's a sort of awareness among researchers in this area that frequency of sex and sexual desire are two intercorrelated factors. Nonetheless, more research has to be done on what can be called "release of sexual tension" and the effect of an accumulation of sexual tension.

A step forward in indirectly assessing sexual desire by looking at sexual intercourse can be found in those studies where, in order to measure female sexual desire, the authors distinguish between "frequency of intercourse" and "frequency of intercourse initiated by the woman" (see Bullivant et al., 2004; Carvalheira, Brotto & Leal., 2010; Cawood & Bancroft, 1996; Harvey, 1987; Rooney & Simmons, 2013). However, deciding "who initiated a sexual intercourse" may sometimes be difficult. Thus, there's a risk that such a measure is influenced by the participant's own perspective. Furthermore, the dynamics in sexual roles can be strongly dependent on the sexual partner and/or type of relationship. Let's take for example a committed heterosexual couple in which, as a sort of role play, it's usually the man

who takes the initiative. Although the woman may experience an increase in sexual desire around ovulation, rather than initiating more often sexual intercourse she would become more receptive. Thus, this would still be a relevant change in the woman's sexual behaviour, although it would not translate into a measured increase in frequency of "initiated intercourse".

Given the studies and the reasons cited above, I therefore conclude that overall frequency of sexual behavior can be an informative, objective indicator of subjective sexual attitudes that should be assessed in sexuality studies; however, neither the frequency of sexual intercourse nor the number of sexual intercourses initiated by the woman represent a reliable way to indirectly assess sexual desire.

**Masturbation and the concept of Solitary Sexual Desire**

A much less common measure used to assess sexual desire regards *solitary* sexual desire or, in other words, desire for masturbation. As already stated above, women do not always have sex with a partner in response to a high level of sexual desire (Meston & Buss, 2007). Thus, what they report as increased *dyadic* sexual desire (i.e., desire to have sex with a partner) could be better described as, for example, desire for intimacy (Basson, 2002). On the other hand, desire for solitary sex doesn't involve any type of relationship with or feelings toward another person, thus, allowing for a purer index of desire for experiencing sexual pleasure. However, Dosch, Ghisletta and Van Der Linden (2016a) found that solitary sexual desire is negatively influenced by body-image, and that this relationship is mediated by the presence of distracting negative thoughts about their own body. Surprisingly, the same did not apply to dyadic sexual desire. These results basically suggest that worries like "my tights are too large" or "I hate my belly" are more distracting during masturbation than during a sexual intercourse. Nonetheless, it should be noted that this data comes from women in a stable relationship, lasting between 3 and 29 years. If instead, women in a new relationship or

who have only occasional sex with different partners were asked to participate in such a study, results might have been different. That's because the effect of not being comfortable with their own body may be mitigated by intimacy and comfort built within a long-term relationship.

A different study conducted by Jones, Hahn, Fisher, Wang, Kandrik and DeBruine (2018) indicates that not only are dyadic sexual desire and solitary sexual desire differently influenced by the same psychological factors (e.g., body-image related thoughts), but that there are also differences in how the two are influenced by hormones. In this regard, Jones et al. (2018) collected saliva sample from 375 women across repeated sessions and administered the Sexual Desire Inventory (SDI). Correlations between SDI scores and hormones were then tested via linear mixed models, which allowed them to test for the effect of different combinations of progesterone, estradiol, testosterone and cortisol, and interactions, on sexual desire. While a negative effect of progesterone and a positive effect of estradiol were found on general sexual desire (i.e., SDI total score), only progesterone had a significant negative effect on *dyadic* sexual desire. On the contrary, only estradiol showed a positive significant effect on *solitary* sexual desire. Cortisol and testosterone did not appear to have any effect on any type of sexual desire.

In conclusion, these studies support the importance of distinguishing between dyadic and solitary sexual desire, which appear to be differently associated with various biological and psychological predictors (as in Jones et al., 2018). After more than 20 years, by also addressing the distinction between desire for masturbation and desire for sexual intercourse, the Sexual Desire Inventory, developed by Spector and colleagues (1996), still remains the best available measure to investigate sexual desire.

## Chapter 2: Menstrual Cycle, Mood and Sexual Desire

Research on changes in sexual desire has followed two primary directions. On one hand, researchers have discussed direct and indirect changes in sexual desire attributable to hormonal effects by looking at changes across the menstrual cycle. On the other hand, psychologists and clinicians have also analyzed personality characteristics, cognitive mechanisms, and affective mechanisms that may influence sexual desire and behavior, mostly by comparing individuals with and without sexual dysfunctions. In the following chapter, I will discuss studies coming from these two main approaches and underline important findings and limitations.

### The role of the Menstrual Cycle in Female Sexual Response

Research on the association between sexual desire and the menstrual cycle has followed different theoretical lines, and in this thesis, I will focus on two of them. The first and most common line of research aims at supporting the idea of an increase in sexual desire and behavior around ovulation, which would be functional to reproduction (meaning increased sexual activity around the most fertile period) (Caruso et al., 2014). The second line instead, tries to better understand indirect mechanisms associated with variations in sexual desire and behavior, linked for example to the relationship with the partner (Eastwick & Finkel, 2012) or to more cognitive and contextual aspects (Giles, 2008). Even though to date it's clear that menstrual cycle phase and hormone levels can indeed influence female sexual desire, and that these influences might also be mediated by specific cognitive mechanisms, results from past research are still controversial, due to inconsistent results and methodological differences across studies.

***The association between a peak in Sexual Desire and Fertility***

Let's discuss the first line of research, which has focussed on evolutionary models that predict periovulatory increases in desire and sexual activity, thus increasing the likelihood of sexual activity during the most fertile days of the cycle (Caruso et al., 2014). As anticipated above, studies from this area have provided inconsistent results that are often limited by methodological weaknesses. For example, Stanislaw and Rice (1988) investigated the correlation between ovulation and sexual desire by monitoring changes in basal body temperature (BBT) - which can be used as an indirect measure of hormonal changes around ovulation. Participants were required to report the day of the BBT shift (i.e., day of ovulation), if they experienced sexual desire (by crossing the day of the calendar in case they did experience sexual desire), whether and when they had intercourse around ovulation, and the general frequency of sex on a monthly basis. Although results revealed that around 50% of the participants experienced an increase in sexual desire around BBT shift, meaning during the fertile period, some major limitations make these data uninformative. For example, sexual desire was measured as a dichotomous variable (sexual desire on/off), in order to detect an "onset" of sexual desire. However, I would argue that sexual desire is a much more complex phenomena that should be discussed both in terms of valence and intensity, thus, along a continuum rather than as an on/off phenomena. In addition, in order to get variability in the predictor (i.e., presence/absence of sexual desire), data from women experiencing sexual desire every month were excluded from the analyses. Such a choice might have limited the sample of women included in the analyses to women with low sexual desire. Finally, women included in the sample were following a family planning protocol, meaning that one constraint to sexual behavior was already automatically imposed by the research protocol, thus, interfering with the effect of the menstrual cycle under investigation. In conclusion, the

study presented above lacks an appropriate definition of sexual desire and does not provide clarifications on changes in sexual desire around ovulation.

More recently, Roney and Simmons (2013) also concluded that desire peaks around ovulation. Furthermore, the authors offered a biological explanation to their hypothesis, suggesting that the peak in desire was associated with an increase in estradiol. In order to test for this association, women were asked to collect saliva samples daily, for 2 months, to assess for levels of estradiol, progesterone and testosterone. Thirty-six women completed hormonal and sexual desire assessment for the 2 full months. Mixed models were employed to test the data at both group and subject levels. Overall, progesterone and estradiol showed a negative and positive effect, respectively, on sexual desire, acting as complimentary to each other. Interestingly, the authors found that differences in mean levels of progesterone, estradiol or testosterone were not associated with differences in mean levels of sexual desire. So, for example, even if woman A has a higher average level of estradiol than woman B, it doesn't mean that woman A will report a higher average level of sexual desire. However, changes occurring within-cycle (and in the same woman) in estradiol and progesterone were predictive of positive and negative changes in sexual desire, respectively. These results were discussed as supporting the presence of an increased sexual desire around the fertile period. Nevertheless, by looking at the data presented in the study (Fig. 1) it is clear that the observed changes represented a *premenstrual decrease* in desire, rather than a *periovulatory increase* (see also Clayton, Clavet, McGarvey, Warnock & Weiss, 1999, who found a premenstrual decline, rather than a periovulatory increase).

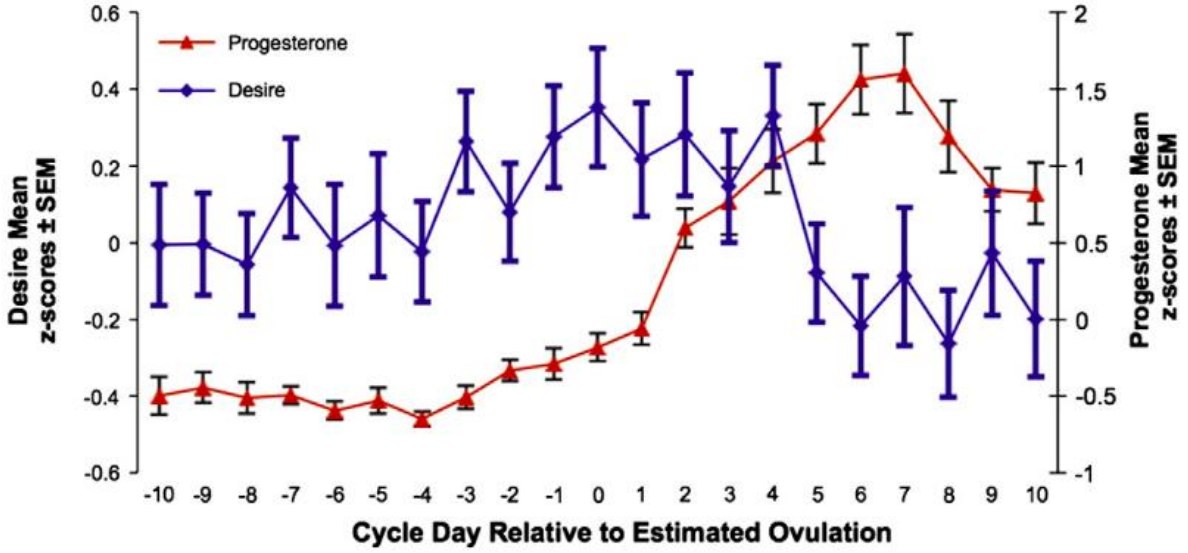


Figure 1: Figure taken from Roney and Simmons (2013). On the x-axis time is calculated in days relatively to the day of estimated of ovulation (which is represented by the 0). Values for desire are standardized within-cycles such that zero on the primary y-axis represents the mean desire for sex within a given cycle.

The idea of a periovulatory increase in sexual desire has also been challenged by Bancroft, Sanders, Davidson and Warner (1983) who found an increase in desire in the mid-follicular phase, but not in the late follicular phase (thus, not during the periovulatory phase). Van Goozen, Wiegant, Endert, Helmond and Pool (1997), on the other hand, did find a periovulatory peak in desire around ovulation, but only among women with "premenstrual complaints", while those without premenstrual complaints reported higher levels of desire premenstrually. Therefore, when looking at changes in sexual desire around ovulation, one should compare each phase of the menstrual cycle with each other, without exclusively looking for changes around a specific time period, like ovulation, assuming that the measured indexes remain stable across the rest of the menstrual cycle. In addition, Van Goozen's (1997) study indicates that other factors, such as the presence of a premenstrual disorder,

might play a role in moderating the timing of changes in sexual desire across the menstrual cycle.

On this topic, Caruso et al., (2014) investigated changes in sexual desire and activity across the menstrual cycle emphasizing differences between women with and without a stable partner. Data were obtained from a prospective cohort study including 1180 sexually functional women, with a regular menstrual cycle and not taking any hormonal contraceptive, ranging from 18 to 40 years of age. The study protocol required participants to record every day for one-month different types of sexual activity (intercourse, masturbation, foreplay, etc.), while also keeping track of the day of their menstrual cycle. Blood samples were collected during the follicular, periovular and luteal phases.

Two main findings were presented. First, regarding baseline measures of sexuality collected with the Female Sexual Functioning Index (FSFI), women with a partner reported higher indexes of arousal, but they were lower in frequency and ability to reach orgasm, compared to single women. Second, women-initiated sexual activity was higher around the periovulatory phase compared to all the other phases of the menstrual cycle and, in addition, this within-cycle difference was higher in single women than in women with a partner (Fig 2). In fact, overall, sexual activity in women with a partner seems less variable across the menstrual cycle. However, even though the daily measure used allowed women to distinguish between self- and partner-initiated sexual activity, different types of sexual activity (e.g. foreplay, sex toys, caressing, masturbation, vaginal intercourse) were not differentiated, so that it's unknown whether the increase in the periovulatory phase showed in Fig 2 refers to, for example, only caressing, only vaginal intercourse or both.

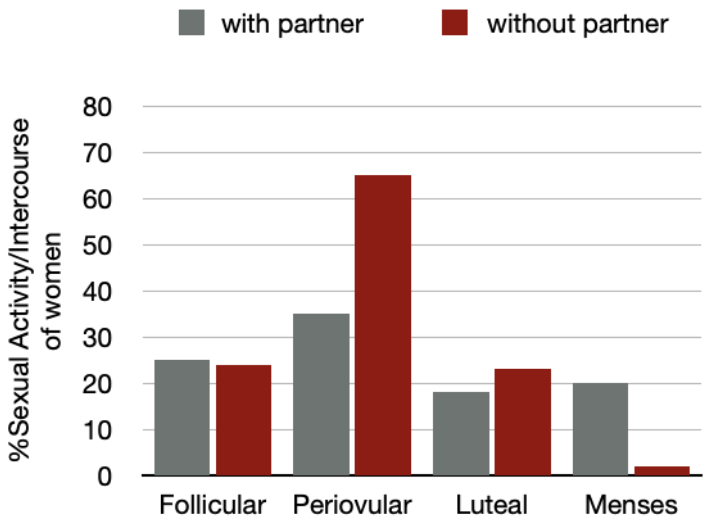


Figure 2: Reproduction of the graph from Caruso et al., 2014. Percentage of sexual activity/intercourse initiated by women with and without a sexual partner, at different phases of the menstrual cycle.

Despite the inaccurate measurement of sexual activity, the study by Caruso and colleagues (2014) - which was conducted on a large and well-selected sample (controlling for presence of sexual dysfunctions, use of hormonal therapy and/or contraceptives), and included repeated, objective measures to identify menstrual-cycle phase - provides compelling evidence of a periovular peak in sexual activity. Moreover, the significant difference in sexual desire across the menstrual cycle is almost exclusively relative to single women, whose sexual activity is probably less constrained by a sexual partner's sexual desire. In fact, in the discussion the authors state that: "*This sexual behavior of singles could be nearer to the biological model, more influenced by hormonal activities than that of the women with a partner, on which the influence of psychosocial conditions could limit the full activity of hormones*."

Although it might sound paradoxical, these results therefore indicate that the evolutionary justifiable peak in female sexual desire and behavior around the most fertile period of the month applies better to women without, rather than with, a stable partner, suggesting that reproduction might not be favored by monogamy. Moreover, contrary to the

results found in Rooney and Simmons (2013) - which indicate that estradiol and progesterone are associated with increased and decreased sexual desire, respectively - Caruso and colleagues (2014) found a positive correlation between sexual activity (both in single and partnered women) and androgens, and specifically, with levels of total testosterone and with the free androgen index.

Overall, the studies described above support a role of hormones in changes in female sexual desire and behavior. However, which hormones are responsible for those changes is not yet clear. Moreover, factors like premenstrual complaints or the presence of a stable partner seems to also influence female sexual response and might also overshadow the hormonal influences carried by the menstrual cycle.

***What does ovulation actually influence?***

A different approach adopted by some evolutionary researchers has been to shift the focus from sexual desire to other mechanisms, interlinked with sexual desire, that might be influenced by the menstrual cycle and consequently affect female sexual response. Consistent with the generally hypothesized peak in sexual desire around ovulation, Thornhill and Gangestad (1999) proposed an explanation for why women's *sexual attraction* and mate choice would change based on the phase of their menstrual cycle. According to the authors, humans have acquired through evolution a strategy to use facial symmetry as an indicator of health, and thus, good genes. As a consequence, women consider more symmetrical faces as being more attractive. Following this idea, rather than a general increase in sexual desire around ovulation, Thornhill and Gangestad predicted an ovulatory shift in sexual attraction specifically toward men that possess markers of "good genes" (e.g., men with more masculine aesthetic traits). Note that this doesn't mean that women would prefer more masculine men as partners *in general*, but that they would show this preference specifically around ovulation. As partial support for this theory, Gangestad, Thornhill and Garver (2002)

found a significant increase in attraction to men other than the main partner around ovulation, while there was no statically significant difference in attraction to the main partner across the menstrual cycle. Despite these changes in attraction occurring around the most fertile period, self-reported sexual desire was not found to change across the menstrual cycle. Changes in sexual attraction toward men other than the main partner that are not accompanied by a shift in sexual desire, might not cause changes in sexual behavior. Thus, it's not clear what should be the evolutionary advantage of being attracted by men with genetically-favorable characteristics around ovulation, if such a preference is not followed by an higher rate of reproduction with these men.

Even though these results suggest that changes in how a woman responds to potential partner (but not to the main partner) occur around ovulation, no information was collected on what could drive the preference for potential new sexual partners. Thus, no support for the preference of certain masculine facial characteristics during a specific phase of the menstrual cycle was gained. What is clear instead from the Gangestad et al. (2001) study, but was also highlighted in others (e.g., Caruso et al., 2014), is that sexual desire changes differently in women with and without a partner. However, an important missing piece of information in this study concerns the quality of the relationship with the partner, when present, which has indeed been the focus of another study.

An alternative hypothesis called "the commitment hypothesis" positioned relationship quality at the core of its theory. Rather than a stronger attraction toward men with markers of good genes, Eastwick and Finkel (2012) proposed that "romantic physical intimacy", defined by the authors as "*physical/sexual behaviours (e.g., kissing, sexual intercourse) that are oriented toward or manage to build emotional intimacy between two people"* is what increases around ovulation. In other words, in women within a stable romantic relationship, we should observe an increase in frequency of sexual intercourse around ovulation functional

to strengthening the bond with the partner, and that this association would be moderated by the quality of the relationship.

In support of this theory, Eastwick and Finkel (2012) found an increased probability in engaging in romantic and/or sexual behaviours around the time of ovulation only in those women who reported a strong romantic attachment to their partner. These findings come from 20 women who completed up to 12 questionnaires multiple times across 16 weeks. Backward count procedure was used to identify phases of the menstrual cycle and a dichotomous variable was included in the analyses to differentiate between "fertile" and "non-fertile" days. Analyses focused on the interaction between strength of attachment bond (between the partners) and fertility, in predicting intimate physical contact. Results indeed point toward a moderating effect of strength of attachment bond in the association between fertility and physical contact, so that women with a stronger attachment to the partner had a higher probability of having physical contact with the partner during fertile days. Even though these findings seem to support the commitment hypothesis, claiming that such a difference in dyadic sexual behavior across the menstrual cycle would be driven by quality of the relationship, a simpler interpretation could be proposed. That is: women engaged in a positive, happy relationship could be comfortable with the idea of getting pregnant, or even more, they could be searching for pregnancy. On the other hand, "unbounded" women (as defined in Eastwick & Finkel, 2012) might consciously and actively try to avoid pregnancy, thus, avoiding sexual intercourse around their more fertile period. Simply adding a question about the willingness to get pregnant might have ruled out or confirmed this alternative hypothesis.

The idea that changes in sexual desire associated with ovulation are mediated by factors relative to the quality of the relationship and/or satisfaction toward the partner, is also found in a study by Larson, Haselton, Gildersleeve, and Pillsworth, (2013). In this case,

*partner sexual desirability* was investigated as mediating factor in the relationship between menstrual cycle and changes in evaluation of the partner. Around 100 women, in a romantic relationship, were included in the study. In addition to measuring partner sexual desirability and sexual attractiveness, the authors included several indexes of quality of relationship and attachment bond, including satisfaction with the relationship, commitment, evaluation of partner faults, and emotional closeness to the partner. Data were collected during two sessions and compared across a "high fertility state" and a "low fertility state", identified through urine LH tests. Fertility state was then included as within-subject variable in repeated measures analysis of variance (ANOVA), while indexes of relationship quality were used as dependent variables. Partner sexual desirability and attractiveness were included in the analyses as covariates.

Overall, results suggest that partner's sexual desirability does indeed interact with menstrual cycle phase in determining how a woman feels toward her partner and the relationship overall. For example, it was found that women who considered their partner sexually desirable gave less harsh evaluations of his faults when close to ovulation as compared to when they were in in the luteal phase. Although this study supports the importance of considering the quality of relationship when studying human sexuality in general, and specifically, changes in female sexual behavior across the menstrual cycle, comparisons were conducted only across two periods of time: time around ovulation vs time around the luteal phase. Thus, it's not clear whether the differences found are related to an increase around ovulation, or a decrease around the luteal phase.

Finally, a different line of research has proposed that sexual desire changes around ovulation might not be mediated by psychosocial, but rather cognitive factors, like attention. The philosopher and anthropologist James Giles (2008) hypothesized that a shift in women's attention toward the genitals would occur around ovulation and specifically, that women

would pay more attention to their genitals because more vaginal discharges occur around that period. An alternative explanation that also suggests that changes in sexual desire are an indirect consequence of ovulation and attentional focus, involves changes in the aesthetic perception of the self. In this regard, Bittoni & Kiesner (in preparation) gathered data from more than 600 women through an online questionnaire. Out of 672 respondents, 316 indicated noticing changes in "feeling beautiful" across the menstrual cycle, with 93% of those women experiencing an increase either the week before or the week of ovulation. Similarly, of the 500 women who noticed skin changes and/or feeling bloated across the menstrual cycle, 83% reported a decrease in these symptoms around ovulation. Therefore, rather than attention to the genitals, feeling more attractive together with feelings of general well-being associated with the days around ovulation, might represent the mediating factor between ovulation and sexual desire. In his theoretical article, Giles (2008) continues with a more complex and comprehensive discussion of three ways through which sexual desire can be elicited (each of which is sufficient but not necessary): 1) by external stimuli (e.g., an attractive person); 2) by sexual fantasies; and 3) by internal factors. Hormones fit in the latter category, by enhancing genital sensations and therefore attention to the genitals. However, according to Giles, a change in hormones needs to be noticed in an appropriate context to actually facilitate sexual desire. In other words, sex hormones would indeed predispose women around ovulation to be more prone to experience sexual desire, but in order to produce an actual change in desire the woman should find herself in a sexual context in those days of the cycle (e.g., going for a date with an attractive person) and be aware of her genital sensations. In fact, such an increase in genital sensitivity driven by hormones can also be ignored if experienced, for example, during a walk with a friend.

The position proposed by Giles (2008), Eastwick and Finkel (2012), and Thornill and Gangestad (1999), is that there is a relationship between sexual desire and menstrual cycle,

but that such a relationship can be moderated by a third factor. Different studies have tried to identify this third factor, which might lie in context and awareness (Giles, 2008), but also personality traits (Bancroft & Janssen, 2000), level of attractiveness of the partner (Larson et al., 2013), or length of romantic relationship (Basson, 2000). In addition, moderating effects can intervene in the relationship between menstrual cycle and sexual desire, such as strength of attachment bond with the partner (Eastwick and Finkel, 2012). Past research is therefore indicative of a need of taking into account at least some of the most important factors that can interact with the menstrual cycle and/or sexual desire thus, influencing the relationship between hormonal changes and sexuality.

***Conclusions***

Aside from the concerns raised above, overall limitations for research on menstrual cycle related changes in sexual desire can be summarized as follows. Studies in this area are often limited by small sample size (Van Goozen et al., 1997), weak measurements of sexual desire considering only 1-2 items, sometimes a yes/no response (Stanislaw & Rice, 1988), and by including different types of sexual activity in one item (Caruso et al., 2014), thus lacking sensitivity and specificity to diverse aspects of desire and sexual behavior. Changes in frequency of sexual activity has also been overlooked, even though the availability of one or more sexual partner(s) has the power to shape frequency of sexual behavior (which indeed changes between women with and without a stable partner, as seen in Caruso et al., 2014). Another limitation that almost all the studies cited have in common is not having controlled for individual average levels of sexual activity (both in terms of masturbation and sexual intercourse) and/or sexual desire, which is important to determine the magnitude of the reported changes. In fact, not all individuals have the same average level of sexual desire (Giles, 2008), or *sexual excitation* (Bancroft & Janssen, 2000). Moreover, timing of ovulation has been differently defined and calculated between studies, such as BBT shift (Stanislaw &

Rice, (1988), hormone measurements using urine (Bullivant et al., 2004) or saliva (Anders, Brotto, Farrell & Yule, 2008), ultrasound sonography (Caruso et al., 2014), or ovulation tests (Gangestad et al., 2002). In addition, different methods have been used to define phases of the menstrual cycle overall, including blood samples (Van Goozen et al., 1997), saliva samples (Anders et al., 2008) and backward counting (Suschinsky, Bossio & Chivers, 2014; Eastwick & Finkel, 2012), which makes results difficult to compare. Finally, it's not uncommon to find women within a relatively wide age range included in a study (Van Goozen et al., 1997; Larson et al., 2013), which considering the significant effect of age on sexual desire (Hällström & Samuelsson, 1990; Shifren, Monz, Russo, Segreti, & Johannes, 2008) can be a substantial limitation.

To address the above-mentioned limitations, future research in this field might benefit from having a common/shared methodology, thus allowing for more comparable results. The starting point has to be theoretical, given the need of better definitions of sexual desire. Consequently, better measures for sexual desire would be developed, distinguishing at the very least between desire for masturbation vs desire for intercourse and using continuous variables, to capture both changes in intensity and direction (i.e., increase vs decrease) of sexual desire. It's also clear the need of collecting information about sexual partner availability and type and quality of relationship, rather than just measuring frequency of intercourse. Rather than asking about an overall number of intercourses, some studies (Bullivant et al., 2004; Caruso et al., 2014; Cawood & Bancroft, 1996; Harvey, 1987; Rooney & Simmons, 2013) have measured frequency of intercourse initiated by the women, trying to capture an index of "spontaneous" female desire (a discussion of spontaneous vs responsive sexual desire in Meana, 2010). I would suggest that measuring *desired* frequency of sexual intercourse rather than frequency of intercourse initiated by the woman would probably give us more meaningful indications about female sexual desire. In fact, even if the female partner

initiates the sexual intercourse, one cannot conclude that she wanted to have sex to satisfy an increased sexual desire (see Meston & Buss, 2007 or Basson et al., 2002). Moreover, if measures of sexual activity are included, both men and women should be asked whether they are willing to have sex during menstruation, since Harvey (1987) noted that, among 69 women, approximately 37% claimed they didn't want to have sex during menstruation, and 28% of their male-partners were not willing to. Further, indications on desire for pregnancy are needed, since the desire of getting (or not getting) pregnant would change the timing and frequency of sexual intercourse (see limitations for Eastwick and Finkel, 2012 in previous section). From a methodological aspect, using larger samples and repeated measures is preferable, to capture both within and between subjects' effects. Also, controlling for age, or limiting the sample in terms of age of participants would reduce residual age-related variability. Finally, using a common method to measure menstrual cycle phases and ovulation would allow for more comparable results across studies, and direct hormonal measures would be preferable to indirect measures, such as backward counting, for sake of reliability.

In conclusion, despite the confusion and controversies present in the literature, the existing research indicates that menstrual-cycle-related hormones influence sexual desire. In addition to the studies discussed above, evidence for this comes from studies showing increased sexual desire when using hormone replacement therapy in surgically menopausal women (Sherwin & Gelfand, 1987). It's not clear however, whether the differences between menstrual cycle phases and sexual response are driven by an increase around ovulation or a decrease around menstruation, and if there are factors mediating or moderating this relationship - such as relationship quality (Eastwick & Finkel, 2012), male-partner's behavior toward the female partner (Gangestad et al., 2001), pregnancy desirability, willingness to have sex during menstruation (Harvey, 1987), as well as other factors not related to either the partner or the relationship per se, such as cognitive factors (Giles, 2008). In addition, factors

related to the menstrual cycle, rather than menstrual cycle per se might influence sexual desire. Among others, depression and anxiety could be two of these factors, given that they were found to be associated both with the menstrual cycle (at least in some women, see Kiesner, 2011) and with female sexual response (Kalmbach, Kingsberg & Ciesla, 2014). In the next chapters, the role of anxiety and depression will be thoroughly discussed. Interestingly, while some predictors like relationship quality seem to have a clear directional effect, others like negative mood can influence sexual desire and behavior in a much more complex way. Since negative mood, such as depression and anxiety, is known to vary across the menstrual cycle (Kiesner, 2011) it's possible that menstrual cycle affects negative mood, which in turns affects sexual desire; or interactions among these factors (sexual desire, depression, anxiety and menstrual cycle) may be involved.

**Changing perspective: factors influencing human's sexuality outside the evolutionary framework**

Another important line of theory and research regarding sexual desire comes from a clinical framework and focusses on personality traits and aspects of psychological health, such as mood, that can interfere with or facilitate sexual functioning and sexual desire. Nobre, who is a pioneer in this area, has proposed several measures to examine the cognitive processes that may underlie sexual dysfunction (Nimbi, Tripodi, Simonelly & Nobre, 2019; Nobre & Pinto-Gouveia, 2003; Nobre, 2009). While this work has found several predictors to be significantly associated with desire, including age, psychoticism, lack of erotic thoughts, "failure and disengagement sexual thoughts", thoughts related to female passivity during sex, dyadic adjustment, and health problems (Carvalho and Nobre, 2010), only "failure and disengagement sexual thoughts" remained significant when all other significant predictors were included in the analyses. Thus, to better understand female sexual desire and sexual functioning overall, the psychological and cognitive mechanisms that govern how a woman

feels and experiences sexual pleasure have to be investigated. But to do that, factors that might trigger negative thoughts and moods interfering with sexual functioning need to be identified.

One such factor that has been associated with mental disorder and sexual discomfort is poor body image (e.g., Stice, Hayward, Cameron, Killen & Taylor, 2000; Wiederman, 2000, respectively). Dosch and colleagues (2016), in fact, recently tested the role of body image on sexual desire. This study was conducted on 53 heterosexual women, aged 25 -46 years old, who were engaged in a relationship with the same partner for at least one year. Participants completed a series of questionnaires about sexual desire, including the Sexual Desire Inventory (Spector et al., 1996, so that solitary and dyadic sexual desire were assessed separately), body-image and body-related negative thoughts during sex. Analyses were carried out following the bootstrapping procedure, which allows resampling and decreasing error type 1 in case of small samples and computing hierarchical multiple regressions. In addition to confirming a significant positive correlation between body image and both dyadic and solitary sexual desire, analysis revealed that the presence of body-related negative thoughts during sex was negatively correlated with sexual desire (both dyadic and solitary), and with body-image. The role of body-related negative thoughts during sex was therefore further investigated and, contrary to the initial hypothesis, mediation analyses indicated no effect of body-related negative thoughts on the relationship between body-image and dyadic sexual desire. On the other hand, a mediating effect was present when solitary sexual desire was considered, suggesting that there might be a positive, partner-dependent effect that prevents women with poor body image from having body-related negative thoughts during intercourse, but not during masturbation.

Even though the importance of body-image on female sexuality was confirmed by Dosch et al., (2016) and seems robust, also thanks to a large body of literature supporting the

importance of this factor in women's general well-being (Stokes & Frederick-Recascino, 2003), findings from this study should be considered relevant only when discussing sexual desire in women in a long-term relationship. The reason can be found in both Dosch's (2016) analysis from the same study, but also in previous studies (Basson, 2000; Caruso et al., 2014), which have shown that sexual desire is not comparable between single women and women with a stable partner, and that changes could depend on relationship length. Plus, since only women in a stable relationship were included in the sample, it would have been interesting to also test for a mediating and/or moderating effects of quality of sexual relationship (i.e. dyadic adjustment) on the association between body-image and sexual desire, given the substantial research supporting the influence of dyadic adjustment on female sexuality (González, Viáfara, Caba, Molina & Ortiz, 2006; Trudel, Landry & Larose, 1997), and specifically on body-image (Laus, Almeida & Klos, 2018).

In a second study, Dosch, Rochat, Ghisletta, Favez and Van der Linden (2016b) examined the relationships between sexual desire, sexual activities, sexual satisfaction, and personality traits. All participants (n = 359, males and females) were in a relationship and had been living with a partner for at least 1 year. Such a selection criterion allowed the authors to control for length of relationship and physical proximity to the partner, both of which are commonly overlooked factors influencing sexual desire and activity. Sexual desire, sexual satisfaction, and frequency of sexual activities were the sex-related variables included in the study; whereas, attachment, approach and avoidance motivation, mindfulness, and impulsivity, were all measured to have a personality profile of participants. Cluster analyses were used to group individuals based on their level (low - moderate - high) and type (dyadic and solitary) of sexual desire, and resulted in three groups for men (dyadic, dyadic and solitary, and solitary sexual desire), and three groups for women (dyadic, dyadic and solitary,

and neither dyadic nor solitary sexual desire). These groups were then compared in terms of personality traits.

Results revealed that both dyadic men and dyadic women reported the highest level of sexual satisfaction, high levels of approach motivation (and low avoidance motivation), secure type of attachment, and the ability to focus attention on the present moment (i.e., mindfulness). Additionally, dyadic men had higher levels of self-control compared with men in the other groups. Men in the dyadic and solitary group (i.e., high dyadic and high solitary sexual desire) instead had high levels of impulsivity and poorer self-control, while women in this cluster were more reward-oriented. Finally, men in the solitary group (i.e., high exclusively on solitary sexual desire) and women with a general low sexual desire, reported the lowest level of sexual satisfaction, in addition to a general psychological profile characterized by negative attitudes toward rewards and high levels of avoidance.

Dosch and colleagues' (2016) study provides evidence suggesting two important points. First, there are gender differences in how sex and masturbation are associated with outcome variables. For example, being high in both dyadic and solitary sexual desire was associated with less-favorable personality traits *in men* (e.g., poor self-control), while for women, being moderately high in both types of sexual desire was associated with more positive personality characteristics (e.g., being more goal-oriented). These gender differences are important and should be taken into account when discussing healthy and pathological sexual functioning. That is to say, what works best for men might not work as well for women, and vice versa. Second, there's a link between personality traits, frequency and type of sexual activity, specifically suggesting that, among their sample of people who were in a long-term relationship, those whose sexual desire was moderately high and mainly focused on the partner (i.e., dyadic group), were also those reporting the highest level of sexual satisfaction.

In conclusion, results from these two studies (Dosch et al., 2016a; Dosch et al., 2016b) emphasize the importance of discussing the existence of complex relationships, both direct and indirect, between psychological factors (such as how a woman perceives her own body), cognitive factors (e.g., interpretation of external stimuli), personality traits (e.g., mindfulness and impulsivity), and sexual desire. Previous studies (Geer & Fuhr, 1976; Beck, Barlow & Sakheim, 1983), and a theoretical model proposed by Barlow (1986), anticipated the link between cognitive factors and sexual functioning, considering the effects of cognitive interference on sexual response. In this regard, what Dosch et al., (2016a) called "distracting body-image related thoughts" can be read as a specific type of cognitive interference linked with poor body-image (rather than, for example, fear of performance - as reported in Barlow, 1986) with a negative impact on sexual functioning. But Dosch and colleagues (2016a, 2016b) studies added one more factor to the equation that should not be overlooked by future research, namely individual differences based on personality traits. Nonetheless, rather than a mere summation of the effects carried by each of these factors, future research should pay attention to the interactions between psychological, cognitive, and personality elements on human sexual functioning, controlling also for a consolidating effect of time. Indeed, mechanisms of conditioning could be able to strengthen the associations between negative sexual thoughts - present both *during* sexual activity, as addressed in Dosch et al., 2016a, and *before* sexual activity, in the form of anticipatory negative thoughts (thus, creating negative expectations and leading to a self-fulfilling prophecy) - and negative sexual outcomes. Personality traits might then prevent, or further out promote, such mechanisms.

***Barlow: the effect of Anxiety on Sexual Response***

By differentiating between somatic vs cognitive components of anxiety, Barlow (1986) proposed a model in which the different, and sometimes opposite, effects that anxiety can have on male sexual functioning, are discussed. A clear illustration of these differences is

presented by Beck and Barlow (1986), who monitored changes in genital arousal (i.e., penile tumescence, measured through a strain gauge) and subjective sexual arousal (measured through a lever) associated with different types of attentional focus, occuring during two different conditions of anxiety (anxious vs non-anxious condition). In particular, while exposed to erotic videos, subjects were asked to either focus their attention on their level of erection or their internal feelings. Genital arousal was negatively affected by anxiety in sexually functional men, regardless of where the focus of attention was, whereas men with sexual erectile dysfunction revealed an increased genital arousal under the anxiety condition, but only when focusing on their level of erection (and not on their internal feelings). In terms of subjective sexual arousal instead, no significant change was observed in dysfunctional men across the conditions, while sexually functional men reported the biggest increase in subjective sexual arousal under the anxiety-condition when focusing on the internal feelings. Therefore, not only are genital and subjective sexual arousal independently affected by anxiety, but this effect depends on the presence of erectile dysfunction.

In addition to a different effect of anxiety on sexual response, Barlow (1986) discussed four other aspects that distinguish sexually dysfunctional from sexually functional men. Thus, five differences were identified overall, which were:

1) presence of (sexual) performance-related worries
2) less awareness and control over their erection (i.e., genital arousal);
3) the presence of negative affect in a sexual context;
4) the absence of a significant effect from neutral distractors on their level of genital arousal;
5) the presence of an opposite effect of anxiety on men with and without sexual dysfunction (discussed above).

Note that these five differences should not be thought of as independent and distinct problems, but as a linked chain of events. For example, the presence of sexual negative thoughts, learned through past experiences, and probably facilitated by a genetic predisposition (Bancroft and Jannsen, 2000), makes it difficult for an individual with sexual dysfunction to focus on pleasurable sensations before and during sexual activities. For example, a man who has had past difficulties maintaining his erection during intercourse, may start thinking "*What if it happens again? What if we get naked and I'm not able to get an erection? She'll see that and she will not want me anymore*" (number 1: *presence of performance-related worries*). These types of negative thoughts will be the focus of the man's attention just before or during intercourse, which means he will not able to focus neither on positive thoughts (e.g."*I like this woman so much, it's gonna be wonderful*") nor on pleasurable physical sensations (e.g. "*She's just caressing my harm and it feels so good*" or "I*'m so turned on, I can feel it in my body;* number 2: *less awareness and control over erection*). The repeated experience of such thoughts when in a sexual context, will create a conditioned association between negative affect and sexual context (number 3: *negative affect in sexual context*). Because a man suffering of erectile dysfunction has already focused his attention on these negative thoughts and emotions that have become automatically associated with sexual activity, a neutral distracting factor won't have any negative significant effect on this man's genital arousal (number 4: *the absence of a significant effect from neutral distractors on their level of genital arousal).* In fact, Abrahamson, Barlow, Sakheim, Beck and Athanasiou (1985) observed that, when sexually healthy men were asked to pay attention to a non-erotic audiotape, while watching erotic videos, their level of penile response was reduced - compared to a situation in which they were only asked to watch the erotic videos. On the contrary, a significant difference in penile response between the two conditions (i.e., with and without non-erotic audiotape) was not observed in men with erectile

dysfunction. Similarly, a study conducted in men exposed to erotic videos in an anxious situation, indicates that sexual response under the anxiety-condition varies between men with and without erectile dysfunction (Beck & Barlow, 1986; number 5: "*the presence of an opposite effect of anxiety on men'with and without sexual dysfunction*").

All these observations can be summarized by saying that there is indeed an association between anxiety and sexual arousal which is in turn influenced by the presence of factors listed above. Specifically, sexual-performance related worries, less control over erection, and negative affect in sexual contexts, characterize the presence of sexual dysfunctions and are expected to mediate the association between anxiety and genital arousal (investigated in Beck & Barlow, 1986) and the one between neutral stimuli and genital arousal (investigated in Abrahamson et al., 1985) (see Fig. 3). In the next session, I will contextualize Barlow's ideas in light of other studies, some of which seem supportive of his assumptions while others indicate that some points require clarifications and further distinctions, and therefore that further research needs to be done in this field.

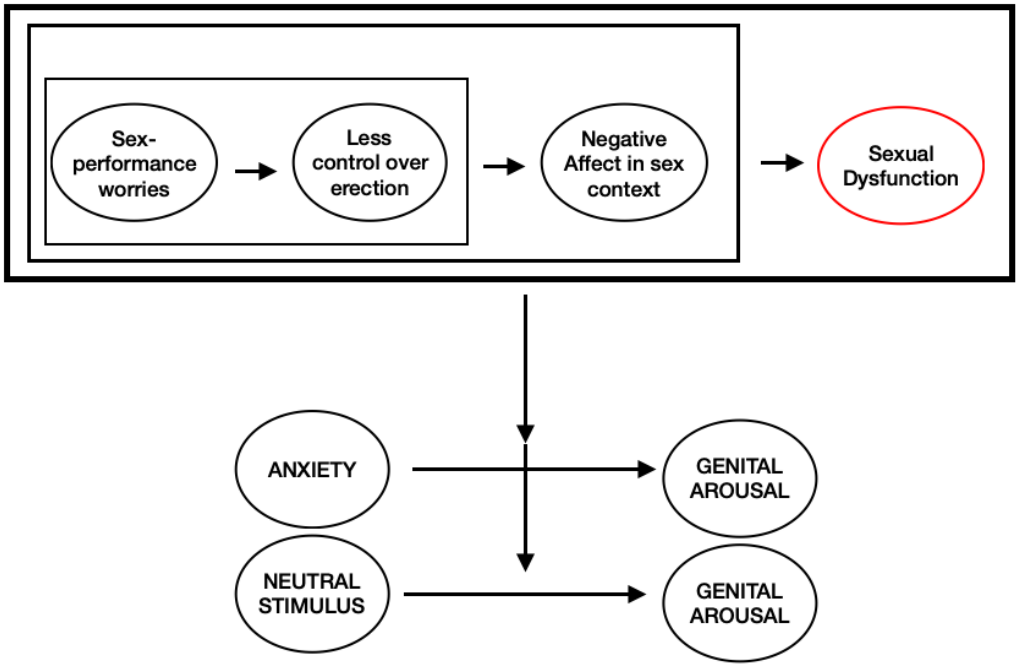


Figure 3: organization of the differences found between men with and without sexual dysfunctions discussed in Barlow (1986).

*Differences between genders and sexual (dys)functioning.* In the previous paragraph I focused on Barlow's (1986) idea that the effects of anxiety on men's sexual response differs between men with and without sexual dysfunctions. However, studies conducted on women suggest that, different from what has been observed in men, an increase in genital arousal following anxious stimuli presentation occurs both in women with and without sexual dysfunctions (Palace & Gorzalka, 1990). In fact, by looking at vaginal blood volume (VBV) (an objective measure of genital arousal) in response to erotic stimuli preceded by anxious or neutral stimuli, Palace and Gorzalka (1990) found that a) when anxious stimuli, rather than neutral stimuli, preceded erotic stimuli, higher changes in VBV were recorded, and b) there's a similar, positive effect of anxiety on genital arousal in terms of *direction* (which is positive in both cases) and *magnitude* in both women with and without sexual dysfunctions. Nonetheless, absolute values of vaginal blood volume were higher in the functional group (note the difference in levels of VBV between functional and dysfunctional women, during

the experimental stimuli period, in Fig. 4). These findings seem to contradict Barlow's assumptions regarding a different effect of anxiety on genital arousal in individuals with and without sexual dysfunctions. At least for women, this might not be the case.

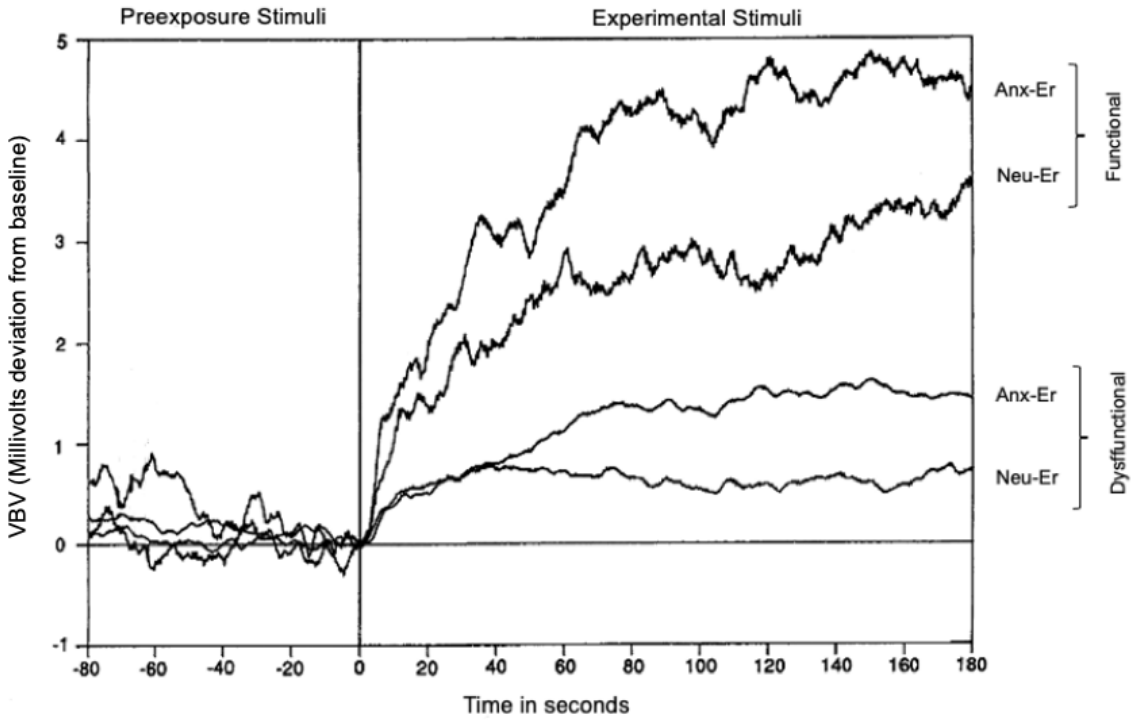


Figure 4: Modified image taken from Palace and Gorzalka (1990). Mean vaginal blood volume sampled 5 times per second in sexually functional and dysfunctional women during two conditions: anxiety provoking stimuli preceding erotic stimuli (Anx-Er) and neutral stimuli preceding erotic stimuli (Neu-Er).

*Types of Sexual Arousal.* Another overlooked distinction is that between different types of sexual arousal. It's particularly important to distinguish between Subjective Sexual Arousal (SSA) and Genital Sexual Arousal (GSA). SSA indicates the inner thoughts, feelings and emotions associated with an ongoing sexual activity (i.e., intercourse or masturbation). We are therefore talking about a mental state of sexual excitement. On the other hand, GSA, usually measured through a vaginal photopletismograph in women (Meston & Stanton, 2019) or laser doppler image in men (Bossio, Singh & Pukall, 2018), is an objective measure of

sexual arousal, which basically records changes in blood flow at the level of the genitals. The importance of differentiating between types of sexual arousal is supported by findings by Beck and Barlow (1986), among others, who found different effects of anxiety and attention (combined) on the two types of sexual arousal. Specifically, among men, there was a statistically significant difference between anxiety plus attention toward erection vs anxiety plus attention toward inner thoughts, on *genital* arousal, but not on *subjective* sexual arousal.

As for men, distinguishing between types of sexual arousal is important to better understand the effect of anxiety on female sexual functioning. Bradford and Meston (2006) measured both subjective and genital sexual arousal in women without sexual difficulties, who've been exposed to relaxing and erotic videos. In addition, measures for state anxiety were administered to the participants, which were then classified as low, moderate or high in anxiety. While an interesting pattern emerged in the association of anxiety with genital arousal, such that the highest positive effect of anxiety on genital arousal was found for women being moderately high in anxiety, no significant association was found between subjective sexual arousal and anxiety.

Taken together, the study by Beck and Barlow (1986) and the one by Bradford and Meston (2006) underline the importance of defining and measuring different types of sexual arousal both in men and women. Such a distinction would allow for a better understanding of the different cognitive and autonomic mechanisms present in individuals with and without sexual dysfunctions.

*Types of Anxiety and Sympathetic Activity.* Following a similar line of thought, it's reasonable to consider the value of separating different aspects of anxiety, whose components can also be distinguished through subjective (e.g., self-report) and objective (e.g., hear rate variability) measures. Thus, it must be asked whether it's the activation of sympathetic nervous system (i.e., autonomic component of anxiety) or the thoughts associated with

feeling anxious (i.e., cognitive component of anxiety) that have an effect on sexual functioning? To better understand the association between sympathetic activity and sexual arousal in women, Meston and Gorzalka (1995) exposed female participants to 20 minutes of intense exercise before showing them one neutral and one erotic movie, while measuring their genital arousal through a vaginal photopletismograph. These measures were repeated on the same women exposed to similar erotic and neutral movies but excluding the physical exercise phase. In this study, in addition to VBV, data on VPA (Vaginal Pulse Amplitude) were also analyzed. The 20 minutes of exercise positively influenced the subsequent levels of both VBV and VPA during exposure to the erotic video but had a significant effect only on VPA (which, according to the authors, would be a more sensitive index than VBV to measure sexual arousal) (see left side of Fig 5). Therefore, a significant effect of increased sympathetic activity on genital arousal was found, although it was not associated with a psychological experience of anxiety, thus representing a rather pure sympathetic activation. Not surprisingly, subjective genital arousal (meaning awareness of sexual physical excitement) was unrelated to objectively measured genital arousal.

Another study conducted in sexually functional women by Lorenz, Harte, Hamilton & Meston (2012) seems to confirm that the increase in genital sexual arousal is not associated with anxiety *per se*, but rather with changes in sympathetic activity. Specifically, the authors found that a *moderate* increase in sympathetic activity was associated with increased female genital arousal, while an opposite effect was observed when sympathetic activity was either too high or too low. In the study, sympathetic activity was measured as heart rate variability, or SDNN as reported in Fig.5 - which indicates the "*standard deviation of the IBI of normal sinus beats*" (Shaffer & Ginsberg, 2017). On the other hand, no effect of sympathetic activity on subjective sexual arousal was recorded (Fig. 5). Such a curvilinear association,

specifically an inverted-U-shaped relationship between sympathetic activity and genital sexual arousal, is relevant when discussing the results presented later on this thesis.

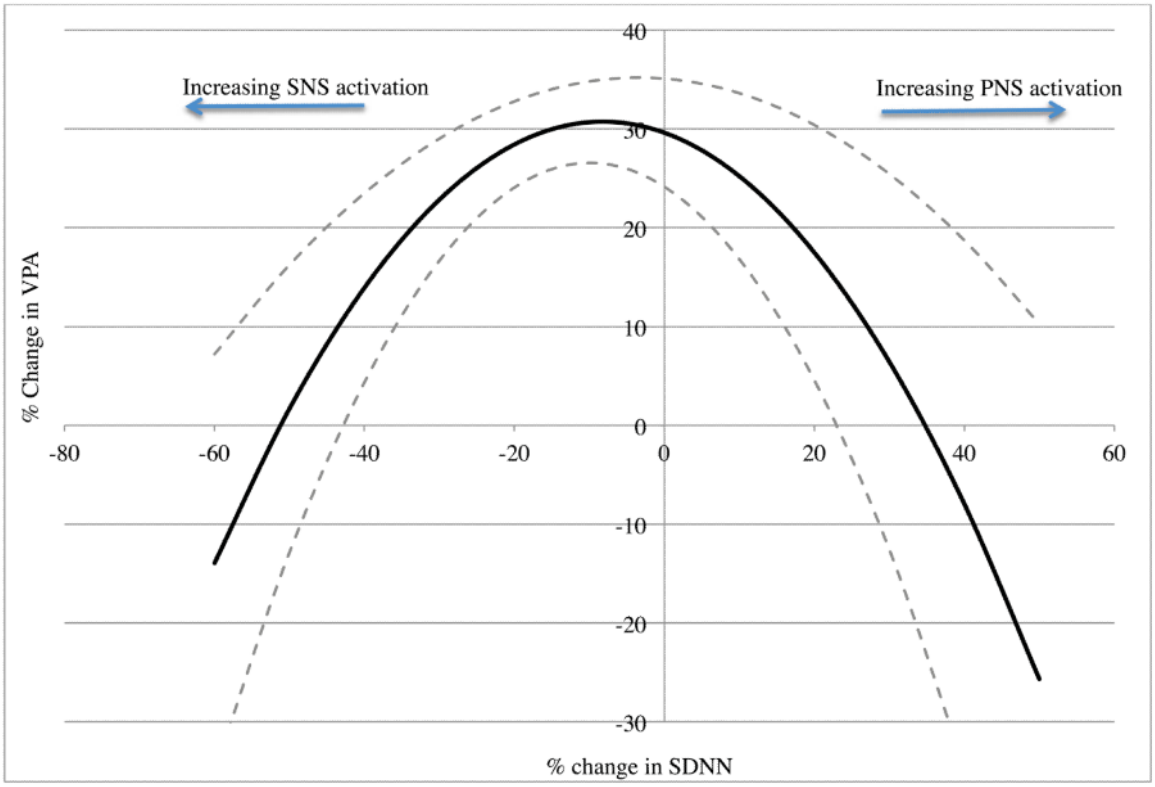


Figure 5, taken from Lorenz et al. (2012): relationship between heart rate variability (SDNN indicates the standard deviation (SD) of beat-to-beat (NN) intervals on a specific timeframe) and genital arousal (VPA). The solid line represents the predicted bold, while the dashed lines represent one SD from the mean.

Nonetheless, in the Lorenz et al. study sympathetic activity was not triggered by any type of stimulation (as, for example, by physical exercise, as done in the study by Meston and Gorzalka, 1995), but simply measured as a spontaneous response to an erotic and a neutral film. A study including both spontaneous changes in sympathetic activity vs changes in sympathetic activity related to the presentation of anxious stimuli, would help clarify the presence and degree of an effect of sympathetic activity on sexual arousal.

An important note that should be made concerns the fact that the association between genital arousal and anxiety is unidirectional, in the sense that if anxiety precedes erotic stimulation, genital arousal increases, but if erotic stimulation precedes the appearance of an anxious stimulus, genital arousal drops (Hoon, Wincze & Hoon., 1977). In conclusion, there's much more that needs to be studied and defined regarding the association between anxiety and sexual arousal, and further research should be conducted paying attention to the distinction between different types of sexual arousal and the components of anxiety. In addition, as anticipated by the results of Beck and colleagues (1983), attentional mechanisms should be included to clarify its role in the relation between anxiety and sexual arousal.

*Attention and Sexual Functioning.* Despite the importance of anxiety's effect on male sexual functioning, the crucial ingredient presented in Barlow's model from 1986 is attention. Note that Geer and Fuhr (1976) had already investigated attentional mechanisms in relation to sexual response. Specifically, these authors tested the idea that exposure to non-erotic material during a state of induced sexual arousal creates "distraction or interference with the cognitive processing of erotic material". Results obtained from male students supported the author's initial hypothesis, according to which, when increasing the complexity of a cognitive mathematical task assigned to the subjects, penile tumescence (i.e., genital sexual arousal) would gradually decreases. Even though sexual functioning of the participants was not evaluated in this study, these data provided convincing evidence of a role of attention on sexual response.

Later studies (Abrahamson et al., 1985; Beck et al., 1983; Beck & Barlow, 1986) further investigated the role of attention, also while analyzing the relationship between anxiety and sexual arousal. In Abrahamson et al., (1985), we can observe a difference of attentional effects on both subjective and genital sexual arousal in men with and without a sexual dysfunction. However, till now we only considered attention as a distracting factor

with a negative effect on sexual arousal. But that's not always the case; in fact, even for attention, a further distinction must be made, depending on the target of attentional focus. A clear example that underlines the importance of the focus of attention is represented by the positive effect of spectatoring for men with erectile dysfunction (found in Beck et al., 1983). Interestingly, this effect doesn't seem to be associated with increased attention toward erection, but rather to a failure in focusing either on erection or inner feelings and sensations associated with genital arousal (see Beck & Barlow, 1986).

*Conclusions.* Taken together, these findings suggest that genital arousal is influenced by attention in both individuals with and without sexual dysfunction, but the direction of such an effect might depend on 1) the focus of attention, but also 2) the interactions of attention with other cognitive mechanisms and strategies specific to individuals with sexual dysfunctions. In fact, studies on both genders suggest that when, during sexual activity, attention is directed to negative thoughts and emotions, a phenomenon called *cognitive interference* (Barlow, 1986) or *cognitive distraction* (Cuntim & Nobre, 2011) occurs, interfering with sexual functioning. Thus, such a phenomenon was identified among individuals reporting sexual difficulties, and might be at the base of, or at least characterize, most psychogenic sexual dysfunctions. Moreover, the effects of different types of anxiety (cognitive and somatic anxiety) should be tested separately, to better understand what are the autonomic, and probably also hormonal, mechanisms associated with the changes found in genital arousal. Finally, the distinction between genital and subjective sexual arousal (for both men and women studies) has to be operated by the use of different measures, to avoid unclear interpretations of results concerning just "sexual arousal".

### *Effect of Negative and Positive Affect on Sexual Response*

Anxiety has been widely addressed as one of the main factors affecting sexual functioning (Bancroft et al., 2003b; Bancroft, Janssen, Strong & Vukadinovic, 2003c;

Barlow, 1986; Lykins, Janssen & Graham, 2006; Janssen, Macapagal & Mustanski, 2013), and usually in a negative way (Kaplan, 1997). However, there are also other affective states that can either interfere or facilitate sexual response.

Bozman and Beck (1991) tested for changes in sexual desire and genital arousal during different affective conditions. Male participants, with a healthy sexual functioning, were asked to listen to three audiotapes describing a sexual encounter between a manand a woman, characterized by a) anger, b) anxiety and c) adequate positive erotic feelings experienced between the two actors in the recording (option c) being the control condition. Changes in sexual desire were obtained from continuous measures derived from a lever that participants were asked to move during the exposure to the audiotapes, according to the level of desire/attraction experienced toward the female of the story. Changes on sexual genital arousal were instead obtained through a device built specifically to measure changes in penile tumescence. In addition, after each stimulus exposure they were asked to fill the Profile of Mood States, a 65-items questionnaire that quantifies the level of tension-anxiety, depression, anger-hostility, vigor-activity, fatigue-inertia, and confusion-bewilderment they just experienced.

Results showed that, whereas the anxiety condition produced no significant differences, when comparing the anger vs positive erotic conditions, the relationship between desire and tumescence resulted to be opposite, such that in the anger condition genital arousal was higher compared to desire, while in the positive condition sexual desire was higher than genital arousal. Hence, as already underlined by other studies conducted in women (Gorzalka & Meston, 1995; Bradford & Meston, 2006), no congruence between genital and subjective sexual arousal (or sexual desire) was found. However, the study by Bozman and Beck (1991) adds another layer, suggesting that the degree of congruence between subjective and genital sexual arousal can vary according to contextual (stimulus) conditions.

In conclusion, this study makes two important points. First, there is incongruence between genital arousal and sexual desire to the point that the two aspects of sexual response might be independently associated to different emotions, such as anger and positive affect. Second, even though it might seem surprising at first glance that the anxiety condition did not provide any significant results, contrarily to other laboratory studies in which evoked anxiety has produced an effect on sexual functioning (e.g. Beck & Barlow, 1986; Gorzalka & Meston, 1995; Palace & Gorzalka, 1990), it should be underlined that the type of anxiety triggered in this study didn't involve neither a strong sympathetic activity (as in Gorzalka & Meston, 1995) nor performance-related anxiety (as in Beck & Barlow, 1986), and thus, it might not have been associated with the activation of self-related negative thoughts about sexual functioning. Therefore, the different contexts and levels of personal involvement required by subjects across these studies makes comparison of results impossible. Rather, considered together, these findings should encourage future researchers to carefully chose the specific components of anxiety to analyze (dividing between the cognitive and autonomic component) and the selection of the stimuli to be used to elicit anxiety, which may or may not be associated with the activation of dysfunctional thoughts about the participants themselves.

Other research attempted to look not only at direct effects, but also at effects coming from interactions between different mood states on sexual response. Peterson and Janssen (2007) used visual stimuli in a similar, more recent study, whose aim was to investigate the relationship between negative, positive and ambivalent mood with sexual arousal and desire. Both male and female individuals were recruited and measures of both subjective and objective (genital) arousal were obtained. Participants were exposed to erotic videos alternated with documentary segments, aimed at getting them back to baseline levels of emotions and arousal before presenting the next erotic video. After each erotic video, participants were asked to rate their level of sexual desire, subjective arousal and 11 emotions

(positive, like “pleasant”, and negative, like “repulsed”) on a scale from 1 to 7. The association between affect and sexual response was therefore examined.

The presence of ambivalent emotions was defined as the co-occurence of positive and negative emotions, rated both with a score higher than 1. With such a low criterion, it’s not surprising that the authors report that most of the subjects experienced “some degree of ambivalence” during the presentation of sexual stimuli. Data were analyzed using step-wise multiple regression analysis, for which the three sexual response indexes (i.e., desire, subjective arousal, and objective sexual arousal) were included as the dependent variables while gender, affect (positive and negative) and condition (type of erotic movie) were included as predictors. Results suggest that the strongest predictor for subjective sexual arousal was positive affect, followed by ambivalence. However, by looking at the figure representing the effect of different mood states, it’s clear that the effect of ambivalence it’s basically exclusively driven by positive affect. Similar results were obtained for sexual desire, which was significantly predicted only by positive affect. Interestingly, genital arousal, instead, did not appear to be linked with affect in general - which is not entirely surprising, especially for women.

Together with the findings presented in previous paragraphs, showing a significant although complex association between anxiety and different aspects of sexual response (e.g., different effects on subjective sexual arousal vs genital arousal) (e.g., Bradford & Meston, 2006; Beck & Barlow, 1986; Palace & Gorzalka, 1990), results from Bozman and Beck (1991) and from Peterson and Janssen (2006) indicate a wider influence of different types of mood on sexual functioning. What we are still far from understand, is how fluctuations in mood states can determine such changes on sexual desire and arousal when other important factors influencing sexual response come at play, such as, quality of relationship and context

(among others). Including moderating and mediating effects in our theoretical models could lead the research to make a big step forward in the understanding of human sexuality.

***Depression, Anxiety and Sexual Desire***

The effect of anxiety and depression remains unclear, as it appears that there are strong between-subjects differences. In fact, in some individuals an increase in anxiety and/or depression has been associated with a *decrease* in sexual desire, although in others the same increase in negative mood was found to be associated with an *increase* in sexual desire (Bancroft et al., 2003c; Bancroft et al., 2003b; Janssen et al., 2013; Lykins et al., 2006). For this reason, Bancroft (2003b, c) and others have referred to this relationship between anxiety and depression with sexual desire as *paradoxical*. These differences in the effect of depression and anxiety on sexual desire can be explained at different levels. First, the cause of negative mood could drive the effect in one direction or the other. For example, if participant X is depressed because she wants to break up with their partner, her depression might be associated with a decrease in sexual desire (thus, desire to have romantic sex); on the other hand, if participant Y's high level of depression is caused by a bad day at work, depression might not have any negative effect on their sexual desire.

Second, personality traits might be a determinant in defining the direction of this relationship. Let's consider again participant Y, and let's suppose she's a woman with high levels of avoidance and low ability in mindfulness (Dosch et al., 2016b, but see also Brotto, Basson & Luria, 2008), two characteristics associated with low levels of both dyadic and solitary sexual desire. We can expect that having a bad day at work or getting a promotion would not have any effect on her levels of sexual desire, which are generally low. On the other hand, if participant Y is a woman high in approach and high in mindfulness from Dosch et al.'s (2016b) study, we could expect to see an increase in sexual desire associated with the work-promotion she just got. Alternatively, she might seek for comfort in sex after a bad day

at work, thus showing an increase in sexual desire. These different effects on sexual desire, coming from the same bad or positive experiences, could be therefore mediated by personality traits. This assumption is further supported by the results presented in this dissertation (see the Results and Discussion sections).

Third, different cognitive strategies used to deal with negative mood might be used by different individuals. These strategies can involve either approach toward, or avoidance of, sex, depending on learning and past experiences (Fisher, Byrne, White & Kelley., 1988). For example, if a woman has learned that having sex is a good way to make her feel more relaxed, she would consider having sex in case she feels anxious or nervous. On the other hand, if she has learned that showing her naked body to another person is something that makes her feel uncomfortable, maybe because of negative body image, she would not want to have sex with someone when she's already stressed. The phenomenon just described was labeled by Master and Johnson (1976) as the *spectatoring effect*, which indicates a situation in which a person's attention is focused on the way their body looks, rather than on the pleasurable sensations coming from intercourse. Thus, this term indicates the process of living the sexual activity from a third person perspective, observing and judging what becomes a "performance", rather than a way to experience pleasure. Fourth, as we already mentioned before, biological factors (such as the menstrual cycle in women) but also genetic predisposition (see "The Dual Control Model", Bancroft & Jannsen, 2000) can influence an individual's sexual desire.

***Physical Symptoms and Sexual Desire***

The role of physical symptoms in sexual desire and sexual functioning is poorly understood, which is likely the combined result of a lack of research and contradictory results across the existing studies. For example, considering headaches, Ifergane, Ben-Zion, Plakht, Regev & Wirguin, (2008) assessed sexual functioning using the Israeli Sexual Behavior Inventory (ISBI) in women with and without migraine. Results showed that, although no significant relationship was found between the presence of migraines and sexual desire, women with migraines reported a lower general score at the ISBI, indicating poorer sexual functioning. In addition, these women reported less sexual satisfaction, a higher incidence of pain during intercourse, and greater fear of penetration.

In a different study, using the Sexual Desire Inventory, Houle, Dhingra, Remble, Rokicki & Penzien, (2006) made an attempt to differentiate between the effects of migraine vs tension type headache (TTH) on sexual desire. Results showed that participants (both male and female) suffering from migraines have higher sexual desire compared to those with TTH - a specific type of headache characterized by head pain rather than nausea, vomiting or photophobia. However, because a healthy-control group was not included, their results are difficult to interpret in terms of an effect of the presence of headaches on sexual desire. Nevertheless, when testing for correlations between sexual desire and specific symptoms, an interesting result was found: the only significant association was a positive correlation between the total score of the SDI and "headache aggravated by routine physical activity". Even though the authors did not include the idea of an optimal level of anxiety in the discussion, nor did they address this result in light of Barlow's model (1986) or Meston's and colleagues' studies (Meston & Gorzalka, 1995; Bradford & Meston, 2006), this data seems, once again, to point toward the presence of a sympathetic influence on sexual desire. Nevertheless, when Bestepe and colleagues (2011) attempted to replicate the Houle et al.

study, but also including a group of healthy women as a control, women with migraines and non-migraine headaches had poorer sexual functioning than matched healthy controls.

Another physical symptom whose presence has been associated with sexual difficulties regards other types of pain. One study examined the presence of sexual desire and frequency of intercourse among patients with different types of chronic (but non-malignant) pain, recruited from a Pain Center and compared with healthy controls (Laursen et al., 2006). Significant differences were found between the two groups, with women suffering from chronic pain reporting less sexual desire, less frequent intercourse (with an average of 2 times per month - which was less than 1/4 as common as compared to healthy women) and believed that sexual activity was less important, compared to healthy women. Moreover, even if women in the pain-group were divided into 4 categories according to which type of pain they experienced, it didn't matter whether the pain involved the viscera, the back, or other muscles - no difference was found between subgroups in their sexual functioning. Even more relevant to this discussion, 58% of women in the pain group reported feeling no sexual desire at all. Unfortunately, however, in this study sexual desire was assessed with a dichotomous question (asking the participant if they had the ability to feel any sexual desire - yes or no), which does not allow us to have an idea about the intensity of the difference found between groups. Finally, the relationship of back pain with sexual functioning has been the focus of a Swedish study in which results indicated that chronic back pain impoverished (e.g., decreased duration of foreplay and less variability in sex positions) and worsened (lower sexual satisfaction) partnered sex life both in men and women (Sjögren & Fugl-Meyer, 1980), although sexual desire was not specifically addressed. Interestingly though, frequency and satisfaction for masturbation remained unchanged after the onset of back pain.

**Final conclusions**

Altogether, the studies presented in Chapter 2 suggest that hormonal, psychological and physical factors have the potential to affect female sexual desire and/or overall female sexual functioning. Aiming at a full comprehension of the associations and interactions among all the above-mentioned factors and their influence on sexual desire, would probably be an unrealistic goal even for a researcher's entire carrier. On the other hand, addressing changes in sexual desire in its associations with *some* of these factors, rather than focusing exclusively on one (e.g., the association between sexual desire and menstrual cycle), is a realistic and preferable approach. By focusing on a selection of three factors that could both directly and indirectly affect sexual desire we aimed at moving one step forward in undressing the complexity around sexual desire. In this thesis, the specific effects of anxiety, depression and the menstrual cycle were under investigation.

## Chapter 3: Introduction and Description of the Current Study

As outlined in Chapter 2, sexual desire and general sexual functioning have been found to be associated with many variables. In addition to those previously mentioned, a developmental history of sexual abuse (Rellini & Meston, 2007; for reviews, see Brotto, Bitzer, Laan, Leiblum, & Luria, 2010; & Leonard, & Follette, 2002) and the length of one's current sexual relationship (Carvalheira, et al., 2010; Klusmann, 2002) have been consistently associated with women's sexual desire. Considering women's sexual functioning more generally (i.e., not specific to sexual desire), evidence suggests that general emotional well-being (Bancroft, Loftus, & Long, 2003), feeling desired and accepted by one's partner (Graham et al., 2004), body-image satisfaction (Graham et al., 2004), sexual conservatism and cognitive interference (Nobre, 2009), psychiatric history (Brotto et al, 2010) and menopausal status (Cawood & Bancroft, 1996), are all important contributors.

The analyses presented in this thesis focus on three main factors previously found to be associated with sexual desire: the menstrual cycle, anxiety, and depression. The influence of menstrual cycle on sexual desire has been widely theorized and tested (Bullivant et al., 2004; Roney & Simmons, 2013), as discussed above (see Chapters 2). However, recent research suggests that this association is very individual, and that a general conclusion that could apply to all women is not justified (Bittoni, Kiesner, Komisaruk, Eisenlohr-Moul, & Pastore, in preparation). Thus, contrary to what has been done so far in the literature, using large samples together with a proper statical approach that would allow to address individual differences, seem to be the most desirable approach for future research.

In addition, anxiety and depression were chosen as predictors of sexual desire to be further investigated given the interesting line of research studies conducted by Bancroft and colleagues at The Kinsey Institute between 2003 and 2013 (Bancroft et al., 2003a; Bancroft et al., 2003b; Janssen et al., 2013; Lykins et al., 2006). These studies report both positive and

negative effects of negative mood on sexual behavior and desire (Bancroft et al., 2003a, b; Bancroft, Janssen, Strong, & Vukadinovic, 2003; Graham et al., 2004; Janssen, et al., 2013; Lykins, et al., 2006), which lead to the description of paradoxical associations between anxiety and depression, with sexual desire. Already 35 years ago Barlow (1986) had proposed a model, based on the then existing literature, indicating that anxiety could have both positive and negative effects on sexual functioning. Barlow's theory, however, focused on sexually functional vs dysfunctional men, and the research that was cited pertained primarily to laboratory manipulations of threat and anxiety (see Meston & Gorzalka, 1995, and Palace & Gorzalka, 1990, for similar laboratory-based research on women). Thus, the relevance of anxiety to sexual desire in the general population and in relation to real-life experiences of anxiety, remained largely unaddressed. Similarly, although past reports have suggested that people with major depression report decreased desire, caused either by depression itself or by antidepressant side effects (Lane, 1997; Montejo-González et al., 1997), the commonly held belief that depression exerts a negative influence on sexual desire has also been questioned. For example, Black and colleagues (Black, Kehrberg, Flumerfelt, & Schlosser, 1997) reported that among both men and women with compulsive sexual behavior, a high percentage showed a 6-month comorbidity for "major depression or dysthymia" (31%); and Mathew and Weinman (1982) found that a sample of drug-free depressed patients demonstrated higher rates of both "loss of libido" and "excessive libido", as compared to a non-depressed control group, although selection bias may have resulted in significant underestimates of sexual dysfunction among the control group. Overall, these data suggest that higher levels of sexuality are sometimes co-occurrent with mood disorders.

Qualitative research has also provided evidence for a paradoxical association between sexual desire and mood problems. Specifically, to identify factors that influence sexual desire and arousal, Graham and colleagues (2004) used focus groups in which women were asked to

discuss what facilitates or interferes with the female sexual response based on their direct or indirect experience. Among several factors discussed by participants as having either positive or negative effects on sexual arousal, such as self-image, or feeling desired vs feeling used, anxiety was found to have a paradoxical association with sexual arousal, with some women experiencing a heightened sexual response when anxious, while others reported the opposite. Although Graham's study was primarily focused on female sexual arousal, many of the women in their study reported not clearly differentiating between desire and arousal, thus, it could be hypothesized that at least some of the factors indicated as affecting sexual arousal could also influence sexual desire. In fact, in the results presented, depression and anxiety are explicitly discussed as influencing both sexual arousal and sexual interest/desire.

More specific tests of the paradoxical effect of mood on sexual desire were conducted on gay and heterosexual men using a measure that provides a more direct test of the association between negative mood and sexual desire. Specifically, the Mood and Sexuality Questionnaire (MSQ) asks participants to attribute changes in sexual desire and sexual performance to changes in anxiety and depression by asking "When you have felt depressed, what typically happens to [a] your sexual interest and [b] your sexual arousal?" and "When you have felt anxious/stressed, what typically happens to [a] your sexual interest and [b] your sexual arousal?". Thus, participants are asked to make causal attributions regarding a possible association between mood and sexuality. Across studies, results showed that while most individuals report either no change or a decrease in sexual desire when experiencing negative mood, there are some individuals for whom sexual desire increases with higher levels of anxiety/stress and/or depression (Bancroft et al., 2003 a, b, & c). In addition, for both gay and heterosexual men, those who reported experiencing increased sexual interest during negative mood states also reported a higher number of casual partners (Bancroft et al., 2004; Bancroft et al., 2003a), such that some men seem to be prompted to search more specifically for casual

sex when experiencing negative feelings. Finally, the positive association between sexual desire and negative mood seems to be especially present among sex addicts (Bancroft & Vukadinovic, 2004).

Most relevant to the current paper are results discussed in Lykins et al. (2006), who found that while 50.5% of women participants reported experiencing a decrease in sexual desire when depressed, 9.5% reported experiencing an increase in sexual desire. This paradoxical effect seems even stronger for anxiety, given that 34% of women participants reported a decrease, while 23% reported an increase in sexual desire when feeling highly anxious. Nevertheless, the paradoxical effect of anxiety and depression on sexual functioning seems to be stronger in men than in women (Janssen et al., 2013).

Overall, the past literature converges on the idea that both depression and anxiety show paradoxical effects on sexual desire – when investigating high levels of negative mood. However, the studies discussed above have limitations that dictate caution when interpreting their results. For example, the Graham et al. (2004) study was based on qualitative methods in the context of focus groups, thus more rigorous measurement and quantitative methods should be used to further test these findings. Also, although Bancroft et al. (2004; 2003a, b, c), Lykins et. al. (2006) and Janssen et al. (2013) provide the most direct test of these effects, they also share an important limitation. Specifically, the studies asked participants to make causal attributions about a putative association between past mood states and past sexual desire, thus adding two layers of potential bias and measurement error. First, recall bias and unreliability has been observed for self-reports of past affective symptoms and non-sexual behaviors (Boschloo, et. al., 2013; Coughlin, 1990; Herrera, Montorio, Cabrera, & Botella, 2017), as well as specifically for sexual behaviors (Jaccard, McDonald, Wan, Dittus, & Quinlan, 2002; Jaccard, McDonald, Wan, Guilamo-Ramos, Dittus, & Quinlan, 2004; Jaccard & Wan, 1995). Thus, results should be taken with caution until further tests can be conducted

with more direct measures of changes in mood and sexual desire. Second, decades of research have shown that people's causal attributions are frequently biased and unreliable (Mezulis, Abramson, Hyde, & Hankin, 2004; Miller & Ross, 1975; Sedikides, Campbell, Reeder, & Elliot, 1998), and although I could find no research specific to errors in causal attributions regarding sexual desire or behavior, they seem likely to exist, and therefore caution should again be applied until these results are replicated without requiring individuals to make such attributions. Finally, a third limitation is that these studies have not tested what associations exist at low levels of negative mood. Although this issue might appear theoretically predictable and less practically relevant, evaluating the effect across the full range of the same emotion would guide us toward a better general understanding of the relationships between sexual desire, anxiety, and depression.

**Presentation of the Current Study**

The aim of the present study was to test and extend the hypotheses and findings of Bancroft et al. (2004; 2003a, b), Lykins et al. (2006), and Janssen et al., (2013), using very different methods. In doing so, the main limitations described above were addressed, namely the use of retrospective reports and requiring participants to make causal attributions regarding the association between negative mood symptoms and sexual desire. Moreover, because past studies have focused on testing for paradoxical effects only at high levels of negative mood, I will examine these association across the full range of mood experiences.

The above limitations are addressed in three ways. First, day-to-day reports, rather than retrospective recall, are used to measure daily changes in mood and sexual desire. Second, to avoid asking participants to make causal attributions regarding negative mood and sexual desire, separate items and repeated measurements were used, without asking participant to infer any type of association on their own. Third, I tested for associations between mood and sexual desire across the full spectrum of mood symptoms. In addition to

these methodological improvements, the present analyses are based on a large sample (n = 213) of women who participated in a study on the menstrual cycle in which they were asked to provide daily reports for two full menstrual cycles (approximately 2 months). Thus, with this high frequency of measurement over an extended period of time, and a large sample, I have modeled individual change across time in all measured variables, as well as covariation in the observed changes. These methodological advancements present significant improvements, and I believe will provide robust tests of the research questions.

Finally, given that fluctuations in depression and anxiety (Kiesner, 2011; Kiesner, Mendle, Eisenlohr-Moul, & Pastore, 2016), as well as sexual desire (Bittoni et. al., in preparation), can be associated with the menstrual cycle for some women, it is possible that observed associations between mood and sexual desire would be confounded with menstrual cycle effects. Therefore, to rule out the possibility that any observed associations between mood and sexual desire are the result of the menstrual cycle influencing both types of variables (i.e., third variable confound), cyclical effects of the menstrual cycle on changes in sexual desire were statistically controlled for. The relationship between menstrual cycle and sexual desire was further studied both at the sample (average) and at the individual level, to clarify previous conflicting results found in the literature about the associations between sexual desire and phases of the menstrual cycle.

## Chapter 4: Methods and Statistical Analysis

### Participants

The data presented in this paper are from a larger study focusing on various symptoms of the menstrual cycle and from which previous reports have been published. These earlier reports have focused on menstrual cycle-related changes in mood symptoms (Kiesner, 2011), headaches (Kiesner & Martin, 2013), and sleep (Van Reen & Kiesner, 2016). However, only the current study, and a study in preparation (Bittoni et al.), have examined sexual desire, and these two studies have addressed very different questions (e.g., Bittoni et al., present a detailed analysis of menstrual cycle effects on sexual desire, including how physical and psychological symptoms of the menstrual cycle may influence sexual desire). So, although there is significant overlap in the methods section of the present report and those of earlier reports, the research questions addressed are very different.

Participants were 213 female university students with a mean age of M = 21.29 years (SD = 4.01). All first-year female psychology students were asked to participate, and efforts were made to include women both with and without menstrual difficulties. Individuals could not participate if they were using hormonal contraceptives or therapy. Individuals who had been diagnosed with a psychological or medical condition for which they had been, or were being treated, were welcomed to participate. However, participants with a seasonal illness (cold/flu) at the time of their next menstrual flow were asked to wait until it had passed before starting (e.g., waiting till the onset of a subsequent menstruation). Participation was anonymous, voluntary, and did not result in compensation. The Ethics Committee of Psychological Research, of the University of Padova, approved this study, and all participants signed an informed consent.

Recruitment was conducted at the end of lectures in first year psychology classes, after all male students were asked to leave the lecture hall. A brief explanation of the study

was given, without providing specific information regarding study hypotheses. A central point that was emphasized during the explanation was the importance of including women who have very different experiences during the menstrual cycle, and that it would be equally as important for women with and without menstrual difficulties to participate. Two other points that were emphasized during the explanation were (1) the personal nature of the questions, and (2) the degree of participation required (daily questionnaires for two menstrual cycles). These points were emphasized to avoid surprise on the part of participants. The overall presentation, including questions and responses, lasted approximately 15 minutes.

Of the 897 individuals who were asked to participate, 320 (36%) responded positively and 577 (64%) responded negatively. Those who responded negatively were given the possibility to anonymously indicate why they chose to not participate, using a single-question multiple-choice format response. The distribution of responses was as follows: 20% did not have a regular menstrual cycle; 40% were using oral contraceptives or some other hormonal-based treatment; 22% had no computer access; 5% were not interested; 6% some other reason; and 7% gave multiple reasons. Of the 320 individuals who agreed to participate, 213 (67%) participated for the full study, providing data for two cycles. The data from these 213 participants are analyzed in the present study.

Research assistants met each participant individually to provide an explanation and demonstration of the on-line data collection procedure, and to review all questions and provide explanations when needed.

The average length of the two menstrual cycles was M = 29.57 days for cycle 1, and M = 30.48 days for cycle 2 (average length of two consecutive cycles M = 60.05 days). The average number of questionnaires for each participant was M = 55.09. Thus, on average, participants missed only 5 of the daily questionnaires across the two menstrual cycles, and a total of 11,735 questionnaires were included in the following analyses.

**Measures**

*Online Questionnaire and Procedure*. With the use of an individual password, participants had access to an online questionnaire. All questions referred to the last 24 hours. All responses were given on a 5-point response scale ranging from 1 = "Not at all" to 5 = "Very much". Participants were asked to begin completing questionnaires on the first or second day of menstruation, and to indicate on which day they were starting. Because data collection was conducted using an on-line questionnaire, the time and date of completion was automatically recorded and saved with each questionnaire. Participants were asked to complete one questionnaire each day. However, if they were not able to do so, or accidentally missed a day, the online questionnaire also allowed participants to complete one questionnaire for the prior day, and one questionnaire for the actual day. To control for this, the first question on each questionnaire was whether it was in relation to "yesterday" or "today". Participants were asked not to go back more than one day ("yesterday"). Of the total number of questionnaires included in the present analyses (n = 11,735), 74% were completed on the actual day, and 26% were completed for "yesterday".

*Sexual Desire*. Sexual desire was measured with two questions regarding increased sexual desire and decreased sexual desire. Both questions were preceded with "In the last 24 hours:", then the questions were "…did you experience an increase sexual desire?" and "…did you experience a decrease in sexual desire?". In the present paper a difference score was used (increased sexual desire – decreased sexual desire) to best capture a similar bipolar measure of sexual desire as used by Bancroft et al. (2004; 2003a, b, c), Janssen et al. (2013), and Lykins et al. (2006). The final score had a range of -4 to +4 (M = .54, SD = 1.41), with negative scores indicating a decrease in desire and positive scores indicating an increase in desire.

*Depression*. The measure of depression was based on the following 4 questions (preceded with "In the last 24 hours…:"): "…did you feel down?"; "…did you feel depressed?"; "…did you feel sad?"; "…did you have crying spells?"). The depression score was the mean of those four non-standardized items. This was done separately for each day.

*Anxiety*. The measure of anxiety was based on the following 2 questions (preceded with "In the last 24 hours…:"): "…did you feel anxious?"; "…did you feel tense or nervous?"). The anxiety score was the mean of those two non-standardized items. This was done separately for each day.

*Menstrual cycle*. Because data were originally collected to investigate changes related to the menstrual cycle, the time and date of completion for each questionnaire was recoded to represent the proportion of each cycle that had passed since the first day of that cycle (day within cycle/total number of days in that cycle). Therefore, all participants, regardless of how many days their cycle lasted, were put on the same metric, ranging from 0 - 1 for each cycle (a 1 was then added to all days in the second cycle). The time variable ranged from 0 - 2, with 0 corresponding to the first day of the first cycle, 1 corresponding to the last day of the first cycle, and 2 corresponding to the last day of the second cycle. To avoid a third variable confound, the effect of the menstrual cycle was controlled for. This was done by including the cosine function of time (i.e., the menstrual cycle) in all analyses, which allowed us to subtract the cyclical changes in sexual desire attributable to the effect of the menstrual cycle.

**Data Analysis - Anxiety and Depression**

The aims of the following analyses were to 1) estimate the average effects (across the entire sample) of depression and anxiety, on sexual desire; 2) test for individual differences across women in those same effects; and 3) identify diverse patterns, across women, in those effects. This was made possible thanks to the collection of daily measures of anxiety, depression, and sexual desire for approximately two months for each participant, and thus, I

was able to investigate how variations in mood are associated with variations in sexual desire for the entire sample together (average effects), as well as for each individual participant separately (individual differences). With individual-level estimates of these associations, I was also able to use cluster analyses to group women based on their patterns of associations between sexual desire and the two mood symptoms.

Moreover, because of the use of daily reports across two full menstrual cycles, and because the menstrual cycle can influence both mood and sexual desire, it was important to statistically control for the effect of the menstrual cycle on sexual desire. This was done by regressing sexual desire on the cosine function of time (across two menstrual cycles), thus capturing menstrual cycle-related changes in sexual desire and removing this possible confound from the main analyses. For the analysis on the effect of menstrual cycle on sexual desire, see the paragraph "Data Analysis - Menstrual Cycle".

Data were analyzed in two steps. First, multilevel (mixed) models were conducted using JMP Pro 15 software (SAS Institute, 2019). In these analyses the following three effects were considered: cyclical effects of the menstrual cycle (cosine of time), linear effect of mood (depressed mood and anxiety), and quadratic effect of mood (depressed mood and anxiety). All three of these effects were treated both as fixed effects (e.g., average effects across the full sample) and as random effects (e.g., with the effect estimated separately for each individual participant, and testing for individual differences across participants). Because participants had different mean levels and different minimum and maximum values of mood symptoms, each mood variable was mean-centered within participant prior to creating the quadratic effect. Note that, sexual desire scores also show mean-level differences across participants, but those differences are specifically modeled in the analyses, so centering that variable is neither useful nor desired.

***Linear and Non-linear Associations***

Regarding the effects of depressed mood and anxiety, both the linear and quadratic (curvilinear) effects are included, to test whether depression and anxiety are associated with changes in sexual desire, and if so, whether those associations are linear or non-linear. Moreover, both the linear and quadratic effects are included as both fixed and random effects When the linear and quadratic effects of mood are included in the model simultaneously, they capture both linear and non-linear associations that could have a variety of shapes, including linear slopes, exponentially accelerating or decelerating slopes, and ∪ or ∩ shaped slopes, representing the association between mood symptoms and sexual desire. Based on past results presented by Bancroft et al. (2004; 2003a, b, c), Janssen et al. (2013), and Lykins et al. (2006), it was expected that for high levels of depressed mood and anxiety there would be some women who experience an increase in desire, and other women who experience a decrease in desire. However, those previous studies only considered changes in desire at high levels of negative mood symptoms, not lower levels of mood negative symptoms, whereas in the present study I am able to examine changes in desire across a range of mood-symptoms within each individual.

***Cluster Analysis***

To group participants based on their individual associations between sexual desire and mood symptoms, cluster analyses based on individual regression slopes were conducted. To do so, the first step included conducting multiple regression analyses separately for each participant including the linear and quadratic (curvilinear) effects of either anxiety or depression as predictors (as stated above, both mood scores were mean-centered within participant prior to creating the quadratic term), and sexual desire as the dependent variable. The two standardized regression coefficients (’βs for the linear effect and quadratic effect) from these analyses were then saved separately for each individual. Next, a two-step cluster

analysis (repeated separately for depressed mood and anxiety) was done, using the saved regression coefficients as variables. First, to determine the optimal number of clusters, the scree plot and dendrogram resulting from a hierarchical cluster analysis (Ward's method) were examined. Second, a K-means cluster analysis was used to classify each individual into a cluster based on the shape of association between mood and sexual desire (e.g., positive, negative, linear, non-linear). Because past research on these associations has only considered the paradoxical effects of mood at high levels of mood distress, there is no prior research to guide hypothesis development for the overall shape of association between mood symptoms and sexual desire when a full range of mood change is considered. Therefore, no a-priori hypotheses were made regarding the number and shape of cluster groups.

It should be noted that conducting these cluster analyses are justified only if there are significant individual differences across participants in the associations between mood symptoms and sexual desire (i.e., random effects of the slopes). Also, the goal of these cluster analyses is to provide descriptive and graphic summary of the observed individual differences in a way that can be used for interpretation and insight.

***Data Analysis - Menstrual Cycle***

Because the effect of the menstrual cycle is modeled as a cosine coefficient of time (thus, the proportion of the two menstrual cycles that has passed), it is important to first describe how these coefficients should be interpreted. Cosine coefficients capture a cyclical "wave" form in change across time, providing a single coefficient that gives both the direction and amplitude of cyclical changes across the menstrual cycle. In this case, a negative cosine coefficient indicates that there is a mid-cycle increase in sexual desire, whereas a positive cosine coefficient indicates that there is a mid-cycle decrease in sexual desire. Examples of cosine regression slopes for the overall group, and a subset of n = 21 participants, are presented in Figure 9, and will be discussed below.

The focus of these analyses was on partitioning the variance into random intercepts, fixed cosine effects of the menstrual cycle (group-level effects), and random cosine slopes of the menstrual cycle (individual-level effects). These analyses included three multilevel models: a null model that included only random intercepts as an effect, testing for mean level differences in sexual desire between participants; a second model in which the fixed effect of the cosine of time was included, capturing the average effect of the menstrual cycle on sexual desire; and a third model in which random slopes of the cosine of time were included, capturing individual variability in the effect of the cosine of time on sexual desire (thus the cyclical changes associated with the menstrual cycle) for each individual. In this way, it was possible to estimate the variance attributable to mean-level variations in sexual desire across individuals, variance attributable to an average effect of cyclical changes of the menstrual cycle, and finally variance attributable to cyclical changes in the menstrual cycle that are specific to each participant.

The variance attributable to random intercepts is simply the intraclass correlation (ICC) and is calculated as the variance component for the random intercepts divided by the total variance from the same model (random intercepts only) and is interpreted as the proportion of the total variance attributable to between-person differences in mean level. The variance attributable to the fixed effect of the cosine amplitude is calculated as the change in residual from the first model (random intercepts only) to the second model (random intercepts and fixed effect of the cosine function) divided by the residual from the first model, which quantifies the proportion of within-person variance accounted for by the average effect of the cosine function (Raudenbush & Bryk, 2002). Finally, the variance attributable to random slopes is calculated as the change in residual from the first model (random intercepts only) to the third model (random slopes and random intercepts) divided by the residual from

the first model, which quantifies the proportion of within-person variance accounted for by individual differences in the cosine function (Raudenbush & Bryk, 2002).

# Chapter 5: Results

## Results – Anxiety and Depression

Results from the multilevel analyses are presented in Table 1. In the top half of Table 1 are the results for depressed mood, and in the bottom half of Table 1 are the results for anxiety. Within each set of analyses the fixed effects are presented in the top half and the random effects in the bottom half. The fixed effects represent the average effects across the entire sample for the cyclical effect of the menstrual cycle (cosine), and the linear and curvilinear (quadratic) effects of each mood symptom. For the fixed effects of mood, the non-standardized regression coefficients are presented and can be interpreted in the following way: the linear effect represents the overall linear trend across the full range of mood symptoms, whereas the quadratic effect provides an index of curvature of the line across the range of mood scores.

Random effects, instead, test for variability across individuals, and a significant random effect indicates that there is variability around the average/fixed effect for the sample. In other words, if random effects result significant, it means that individual women are different from each other with regards to that effect, and thus the average effect for the sample cannot be considered an adequate description at the individual level. Note that, for the random effects, there are no regression coefficients, but rather variance components are used, which are an index of variance that can be attributed to individual differences across women in that specific effect.

As presented elsewhere (Bittoni et al., in preparation), the cosine effect (menstrual cycle effect) was significant and negative, indicating that on average, women demonstrate a mid-cycle peak in sexual desire. Note, however, that the random effects of the intercept were significant, indicating that women are significantly different from one another in their average level of sexual desire. The random effects of the menstrual cycle were also

significant, suggesting differences between-women in how sexual desire changes across the menstrual cycle. These effects are addressed more in detail later on this chapter.

| Predictor | Coefficient | Variance Component | t | 95% CI Wald p |
|---|---|---|---|---|
| Depressed Mood | | | | |
| Fixed Effects | | | | |
| Cosine | -0,22 | | -7.06*** | |
| Depressed Mood | -0,40 | | -7.78*** | |
| Depressed Mood 2 | 0,08 | | 2.31* | |
| Random Effects | | | | |
| Intercept | | 0,43 | | .35 - .52*** |
| Cosine | | 0,16 | | .12 - .20*** |
| Depressed Mood | | 0,27 | | .16 - .37*** |
| Depressed Mood 2 | | 0,09 | | .05 - .13*** |
| Residual | | 1,37 | | 1.34 – 1.41 |
| Anxiety | | | | |
| Fixed Effects | | | | |
| Cosine | -0,23 | | -7.30*** | |
| Anxiety | -0,18 | | -6.54*** | |
| Anxiety 2 | 0,04 | | 1,80 | |
| Random Effects | | | | |
| Intercept | | 0,41 | | .33 - .50*** |
| Cosine | | 0,16 | | .12 - .21*** |
| Anxiety | | 0,07 | | .04 - .09*** |
| Anxiety 2 | | 0,02 | | .01 - .03** |
| Residual | | 1,41 | | 1.37 – 1.45 |

Table 1. Coefficients and test statistics for multilevel model predicting sexual desire difference scores (Increase - Decrease) with fixed effects random intercepts, and random slopes.

* p < .05; **p < .001; ***p < .0001.

Fixed Effects dfs for Depressed Mood: Cosine df = 201.7; Depressed Mood df = 150.4; Depressed Mood2 df = 127.8.

Fixed Effects dfs for Anxiety: Cosine df = 199.9; Anxiety df = 172.4; Anxiety2 df = 156.

Results for depression (top half of Table 1) show that the fixed effects for both the linear and quadratic effects of depressed mood were significant, with a negative linear slope followed by a positive quadratic slope. Thus, on average, for the entire sample, there is an overall negative association between depression and sexual desire, that becomes slightly positive at the high end of depression. However, the tests of random effects showed that significant differences exist across individuals in both the linear and quadratic effects of depressed mood, and thus the average effects cannot adequately describe these associations across individual participants. That is, individual women are different from each other in their relation between depression and sexual desire, and one curve for the entire sample is not adequate to describe this relationship. This variability across women will be addressed below.

Results for anxiety (bottom half of Table 1) present a similar picture, with the exception that the quadratic fixed effect of anxiety was not significant. Thus, on average, for the entire sample, there is only a significant negative association between anxiety and sexual desire. However, both random effects of anxiety (linear and quadratic) were again significant, indicating that significant differences exist across individuals in both the linear and quadratic effects of anxiety, and thus the average effects cannot adequately describe these associations across individual participants.

***Cluster Analysis***

Given the above set of analyses, cluster analyses were used to test whether women could be classified based on their individual pattern of association between mood symptoms and sexual desire. For these analyses the standardized regression coefficients (’βs) for the

linear and quadratic effects were saved separately for each individual (taken from separate individual regression analyses) and used as variables in a two-step cluster analysis. For both mood symptoms the hierarchical cluster analysis (non-standardized) indicated the existence of three groups. Next, using a K-means cluster analysis, each individual was classified into one of these three groups.

Regression lines showing each cluster's association between levels of mood symptoms and changes in sexual desire are presented in Figure 6, and regression analyses testing for linear and quadratic effects of each mood symptom, separately for each cluster group, are presented in Table 2. Considering the slopes (Figure 6) and significance tests regarding each cluster (Table 2), descriptive labels were given to each of the cluster groups. When considering the association between depressed mood and sexual desire, the largest cluster was the Negative Decelerating cluster (n = 96) that is characterized by a significant negative linear trend followed by a significant positive change in the slope, indicating that the initial negative slope flattens out, and possibly becomes positive. The second largest cluster was the Negative Accelerating cluster (n = 92) that is characterized by an overall flat slope (non-significant) followed by a rapidly accelerating negative slope. Finally, a Positive Paradoxical cluster (n = 25), which was named as such because within the same group there appears to be a paradoxical effect, whereby increases in desire are associated both with high and low levels of depressed mood.

When considering the association between anxiety and sexual desire, the largest cluster was the Negative Linear cluster (n = 113) that is characterized by a significant negative linear trend followed by a non-significant quadratic effect, indicating that the same basic trend applies across all levels of anxiety. The second largest cluster was the Negative Paradoxical cluster (n = 58) that is characterized by an initial positive slope (significant) followed by a significant negative curvature in the slope, thus showing a paradoxical effect

| | Depressed Mood | | |
|---|---|---|---|
| | Negative Accelerating | Negative Decelerating | Positive Paradoxical |
| Depressed Mood | 0.04 | -.53*** | -1.34*** |
| Depressed Mood$^2$ | -.21*** | .16*** | .59*** |

| | Anxiety | | |
|---|---|---|---|
| | Negative Linear | Negative Paradoxical | Positive Paradoxical |
| Anxiety | -.21*** | .16*** | -.56*** |
| Anxiety$^2$ | 0.02 | -.16*** | .29*** |

Table 2: Linear and quadratic coefficients for pattern groups of depressed mood and anxiety. In all models the fixed effect of cosine, as well as the random effects of intercept and cosine, were also included but are not presented in the table. In all cases those effects were significant and in the same direction as in the initial analyses presented in Table 1.

within this group, whereby low levels of sexual desire are associated with both low and high levels of anxiety. Finally, also for anxiety, a Positive Paradoxical cluster (n = 42) was observed, in which, within the same group, there is a paradoxical effect, whereby higher levels of desire are associated both with high and low levels of anxiety.

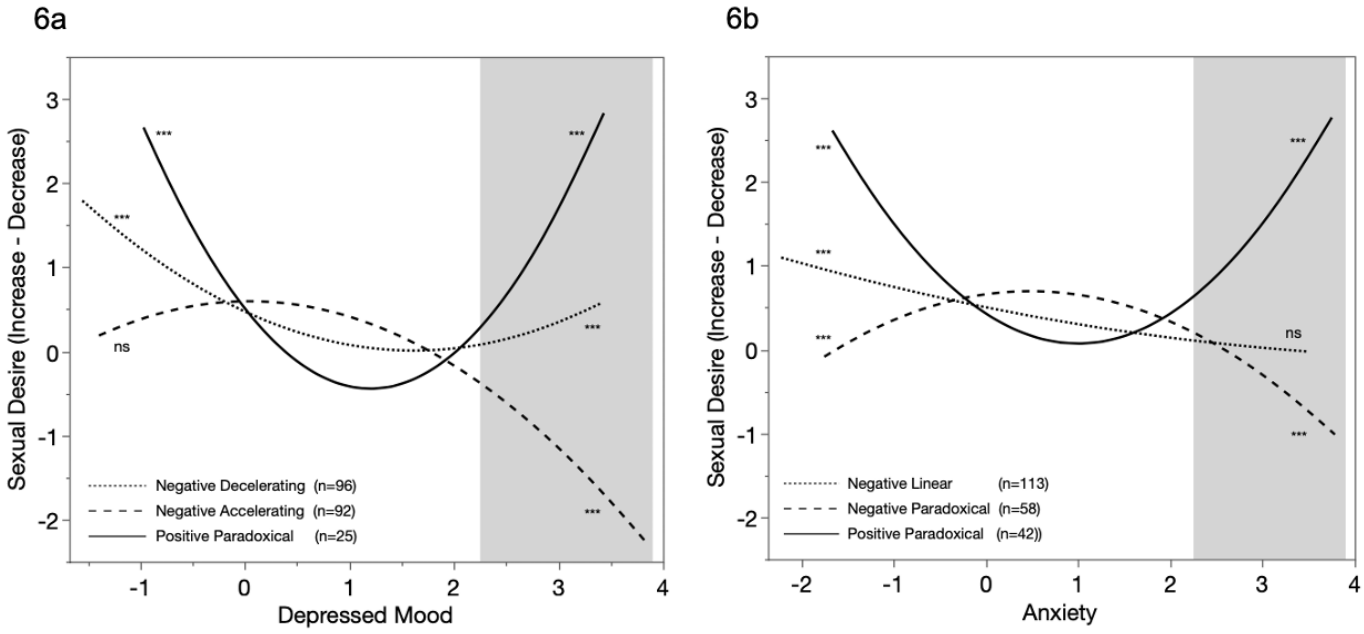


Figure 6: graphic presentation of the results obtained from Cluster Analysis for depression (on the left) and anxiety (on the right). Three groups of women were identified for depression and labeled as follow: negative decelerating (dotted line); negative accelerating (dashed line); positive paradoxical (solid line). Three groups of women were also identified for anxiety and labeled as follow: negative linear (dotted line); negative paradoxical (dashed line); positive paradoxical (solid line).

It should be noted that the replication with past research (Bancroft et al., 2004; 2003a, b, c; Janssen et al., 2013; Lykins et al., 2006), is evident in the right side of Figures 6a and b, for high levels of depressed mood and anxiety (shaded area of these figures). The novel findings regarding the broader associations between mood symptoms and sexual desire, on the other hand, are evident when considering the full range of mood symptoms, and thus the full curvilinear slopes presented in Figure 6a and b.

**Results – Menstrual Cycle. Partitioning of Variance: Comparisons Across Models**

For the following analyses the priors assigned to the various parameters are essentially Student's t with 3 dfs centered on zero (skeptical priors) that differentiate only the

assigned variability; in particular the intercepts $\beta 0k \sim t(3, 0, 2.5)$, the coefficients associated with the predictors $\beta ik \sim t(3, 0, 2)$, and the residuals $\sigma \sim t(3, 0, 2.5)[0,]$.

The first model included only random intercepts of sexual desire, explaining 21.5% the overall variance (ICC = .215; variance component estimate = .44; 90% credible interval = .36 to .52). In other words, 21.5% of the overall variance in changes in sexual desire is explained by between-person differences in their mean level of sexual desire (see Figure 7 for a graphic representation of individual mean levels of sexual desire around the sample's mean). Thus, it can be interpreted as about one-fifth of the variability in changes in sexual desire is attributable to a trait-like stable characteristic, at least within the context of the time-period of the two menstrual cycles examined in this study.

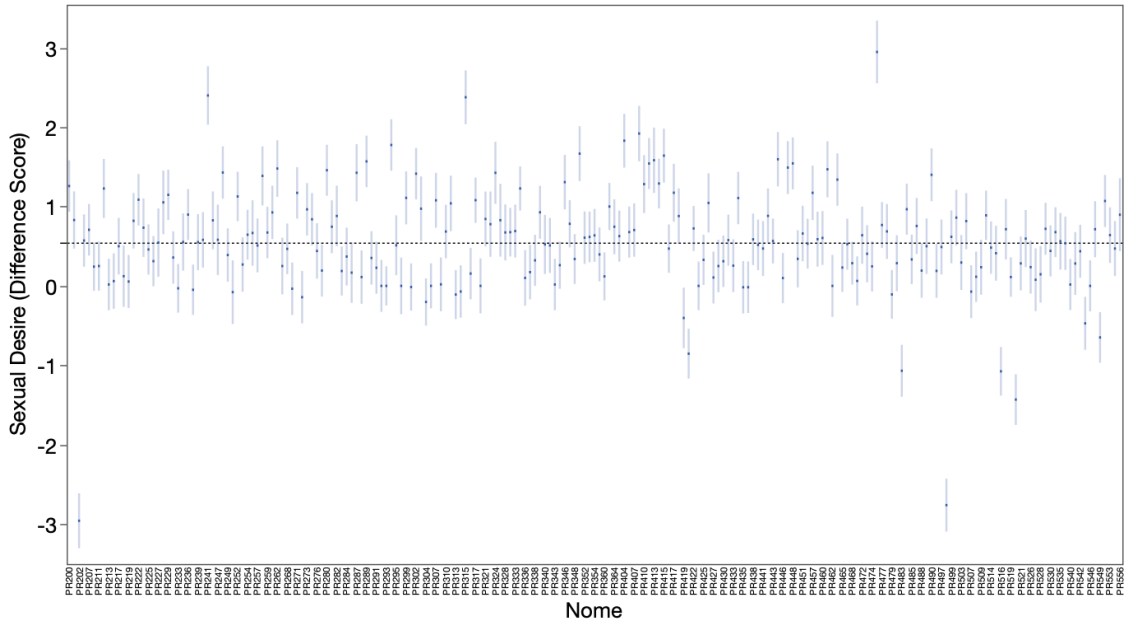


Figure 7: representation of individual mean levels in sexual desire around the sample's mean. On the x-axes there are the participants' codes (Nome). The y-axes represent the entire range for the difference score between increase and decrease in sexual desire. The horizontal dotted line represents the mean level of sexual desire for the entire sample. Each vertical line represents one participant's mean level of sexual desire (the dot within the line), and its 95% confidence interval.

In the second model the fixed effect of the cosine function of time (average effects of the menstrual cycle) was added, testing for group-level cyclical changes in sexual desire across the entire sample, and resulted in a cosine regression coefficient = -.24 (90% credible interval = -.27 to -.22). The negative sign of the cosine regression coefficient indicates that, on average, women experience an increase in desire around the mid-cycle, or close to ovulation (Figure 8). However, the percentage of within-person variance explained by this average effect of the cosine function was 1.6%. Thus, although credible, this effect is small, suggesting that women cannot be accurately described by an "average effect" of the menstrual cycle.

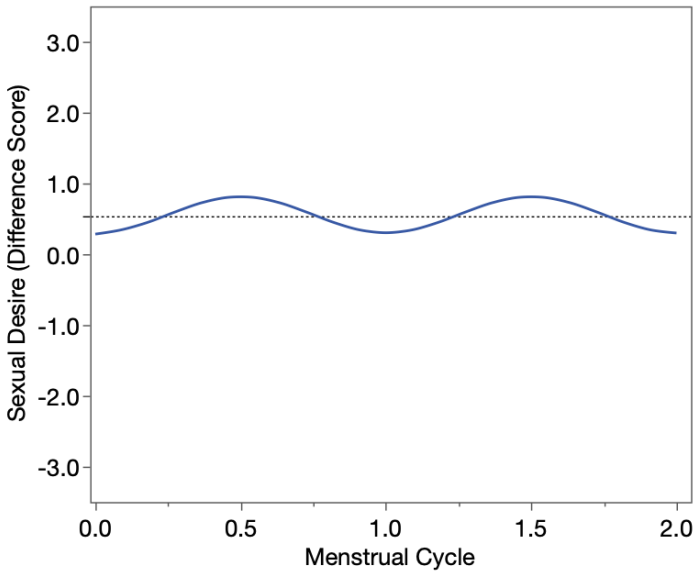


Figure 8: Average effect of the menstrual cycle across the entire sample. The negative cosine coefficient results in an increase around ovulation (0.5 and 1.5).

Finally, in the third model, the random effect of the cosine function (individual-level effects of the menstrual cycle) was added and resulted in a variance component estimate = .19 (90% credible interval = .15 to .23). The percentage of within-person variance explained by individual differences in the effect of the menstrual cycle on changes in sexual desire was 7.8%. Thus, the effect size for these random effects of the menstrual cycle are more than four

times greater than the effect size of the fixed effect of the menstrual cycle, indicating that the average effect of the menstrual cycle is not sufficient for describing individual change in sexual desire, and confirming the presence of in individual differences in how sexual desire changes across the menstrual cycle.

Cosine regression slopes, showing the fixed effect of the menstrual cycle on sexual desire for the entire sample is presented in Figure 8, whereas individual slopes for a selected subsample of n = 21 participants are presented in Figure 9. Note that the participants presented in Figure 9 panel were selected to demonstrate the between-person variability in menstrual cycle effects that was demonstrated in the statistical analyses. As can be observed in these figures, although there is a general tendency for women to experience a mid-cycle (ovulatory) increase in sexual desire, many women show no such change, and other women demonstrate the opposite pattern of change (i.e., a mid-cycle decrease in sexual desire).

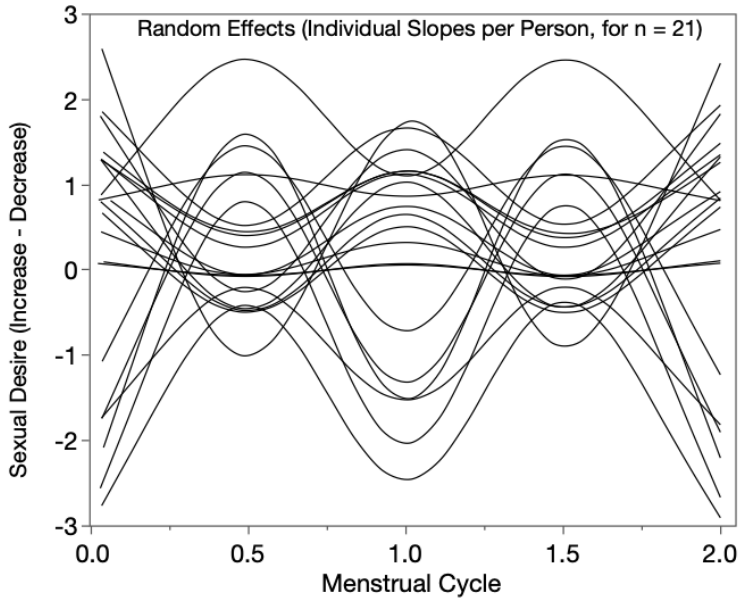


Figure 9: Representation of heterogeneity of menstrual cycle effect on sexual desire in a subsample of women (n=21).

## Chapter 6: Discussion & Conclusions

### Effects of Anxiety and Depression

The present study expanded previous findings of paradoxical associations between sexual desire and both anxiety and depressed mood. Specifically, whereas previous studies examined paradoxical effects only at high levels of negative mood (Bancroft et al., 2004; 2003a,b,c; Janssen et al., 2013; Lykins et al., 2006), in the present study I examined how sexual desire changes across the full range of depression and anxiety. Two important and novel findings emerged. First, a similar between-groups paradoxical association between mood and sexual desire was observed also at low levels of mood symptoms, for both depressed mood and anxiety (see left side of Fig. 6a and 6b). Thus, some women reported an increase whereas others a decrease in their sexual desire, also at low levels of depression and anxiety. This had not been previously tested. Second, some women showed the same change in sexual desire (increase or decrease) at both high and low levels of mood symptoms (see ∪ and ∩ shaped slopes in Fig. 6a and 6b). That is, women in the positive and negative paradoxical groups demonstrated a within-person paradoxical association between sexual desire and negative mood symptoms, in that they reported the same change in sexual desire for opposite levels of negative mood: e.g., an increase in sexual desire when both anxious and not anxious, with low desire at their midpoint of anxiety.

In addition to these novel findings, the between-groups paradoxical association between high levels of negative mood and sexual desire were replicated. These paradoxical associations can be observed on the right side of Fig.6a and Fig.6b, highlighted in grey, where some women demonstrate a decrease in sexual desire and other an increase, when experiencing high levels of negative mood. These results are a clear replication of past work by Bancroft et al. (2004; 2003a,b,c), Janssen et al., (2013), and Lykins et al. (2006). Moreover, an important aspect of the replication of previous results is the similarity in effect

sizes for anxiety, relative to depressed mood. Specifically, the Lykins et. al. (2006) study found that, among women, the paradoxical association (i.e., an increase in desire at high levels of negative mood) is more common for anxiety (23%) than for depression (9.5%); whereas, in the present study, using a very different methodology, a similar difference was observed, with the paradoxical association again being more common for anxiety (19.7%) than for depression (11.7%). Thus, this difference between anxiety and depression in the observed paradoxical associations appears robust across very different methods and samples.

The remainder of this discussion is divided into two main sections. I start with the simplest findings that have been observed in previous studies, focusing on between-group paradoxical associations at the high end of negative mood. The second section will then address the two novel and inter-related findings of the present study: the within-person paradoxical associations, and in doing so, the paradoxical associations observed also at low levels of negative mood.

***Replication of Between-Groups Paradoxical Associations***

Given previous research showing an association between mood disorders (depression and anxiety) and decreased sexual desire (Angst, 1998; Beck, 1967; Cassidy, Flanagan, Spellman, & Cohen, 1957; Figueira, Possidente, Marques, & Hayes, 2001; Schreiner-Engel, & Schiavi, 1986), it was those who reported increased sexual desire when depressed or anxious who Bancroft et al. (2004; 2003a ,b, c) considered to be "paradoxical". Moreover, research showing that depression is associated with diminished interpersonal behavior (Youngren & Lewinsohn, 1980), social withdrawal (Girard, Cohn, Mahoor, Mavadati, Hammal, & Rosenwald, 2014), and anhedonia and fatigue (Gotlib, Lewinsohn, & Seeley, 1995), further suggests that increased sexual desire associated with depression is paradoxical. To understand what drives the paradoxical effect of negative mood on sexual desire, Bancroft et al. conducted qualitative interviews with heterosexual men (Bancroft et al., 2003b) and gay

men (Bancroft et al., 2003c) to identify specific mechanisms for why people respond to negative affect with such different sexual responses. Their results suggested that emotional regulation strategies, such as seeking intimacy and self-validation, likely play important causal roles in creating this paradoxical association. To the extent that the qualitative data from men can be generalized to women, the same causal mechanisms may apply to the new data presented.

It is also important, however, to contextualize depression in terms of its specific causes and in terms of diverse coping strategies that people may use when depressed. For example, consider two women who both score high on depression, but for different reasons. Woman A feels depressed because of chronic interpersonal conflict at work, for which she risks losing her job. Woman B, instead, is living in an unhappy romantic relationship from which she sees no way out. Sexual desire of woman A could be unaffected by negative mood if she is able to correctly attribute her depressed mood to the work context and limit its effects on her romantic relationship. On the contrary, because woman B's depressed mood is strictly linked with her romantic partner, she is likely to actively avoid sex and report low levels of sexual desire. Across these two scenarios, high levels of self-reported depression will have very different associations with sexual desire.

Moreover, different coping strategies could be used for the situations that were described above. For example, woman A might blame her romantic partner for work difficulties (e.g., scapegoating), or vent her negative mood accumulated during the workday towards her romantic partner, thus creating dyadic conflict and indirectly lowering sexual desire. Similarly, women B could use sex as a coping strategy to improve the relationship with her partner, making it appear that her sexual desire is increasing rather than decreasing. Thus, although emotional regulation is likely an important coping strategy that was easily identifiable by participants in Bancroft et al.'s (2003b) qualitative study, and important for

understanding the paradoxical association, there may be other coping strategies not directly focused on affect regulation.

In addition to interpreting their results in the context of affect regulation, Bancroft et al. (2003b) also discussed their findings in light of the Dual Control model of sexual response (Bancroft, 1999; Bancroft & Janssen, 2000). Results from heterosexual men support the idea that individual differences in sexual excitation and inhibition (the key components of the Dual Control model) are associated with the observed paradoxical effects (Bancroft et al., 2003b), but weaker evidence were found for gay men (Bancroft et al., 2003c), and women (Lykins et al., 2006). Thus, to help understand paradoxical effects of mood on sexual desire, the Dual Control model may need to be adapted when applied to individuals other than heterosexual men. More specifically, sexual inhibition in women cannot be conceptualized in the same way as for men (Graham, Sanders, & Milhausen, 2006; Graham et al., 2004), and stimuli that can ignite sexual desire differ between genders (Meston & Buss, 2007). For example, women cited "being used by the partner" or "fear of ruining their reputation" as inhibiting factors (Graham et al., 2004), and partner's acceptance of their body as essential to excitation. On the other hand, fear of performance failure (Bancroft, Graham, Janssen, & Sanders, 2009; Bancroft & Janssen, 2000; Janssen, Vorst, Finn, & Bancroft, 2002) is believed to be an important inhibiting factor in men, who mainly focus on physical appearance and desirability of a partner to augment sexual excitation (Meston & Buss, 2007). One way to make the Dual Control model relevant to the paradoxical effects for individuals other than heterosexual men, is to modify the measurement of the sexual inhibition/excitation constructs (SIS/SES) central to the Dual control model. Lykins et al., (2006), did in fact use a modified version of the SIS/SES, but considering results from Graham and colleagues (2004), simply changing the terminology, for example, to indicate genital arousal (i.e., vaginal lubrication rather than erection) might not be sufficient.

Regarding the paradoxical effect associated with high levels of anxiety, we can again consider Bancroft et. al. (2003b), who suggested that the paradoxical effect with anxiety may be attributable to tension release and the calming effect of sexual pleasure in combination with "excitation transfer" (a concept introduced by Zillman, 2008) of general anxiety to sexual tension/arousal. According to Zillman (2008), the physiological changes occurring in response to anxiety take time to resolve and can therefore persist even after the cognitive response to anxiety has passed. Consequently, this "residual excitation" could influence the perception and interpretation of subsequent, non-anxiety provoking, stimuli. Relatedly, because there are associations between anxiety and sympathetic nervous system activity (Hoehn-Saric & McLeod, 2000), anxiety and provoked sexual arousal (Palace & Gorzalka, 1990), and sympathetic arousal and provoked sexual arousal (Meston & Gorzalka, 1995), it has been hypothesized that an increase in sympathetic activity due to anxiety facilitates sexual response (Bradford & Meston, 2006; Meston & Gorzalka, 1995; Palace & Gorzalka, 1990). In addition, I suggest that this occurs by lowering the threshold required to be receptive to sexual cues, and thus, to perceive an increase in sexual arousal. Although this provides an explanation for why some people may report increased sexual desire when feeling anxious, it doesn't help to explain the existence of individual differences: why some women respond in the expected or non-paradoxical way, and others respond in a paradoxical way.

I propose two possible explanations. One possibility regards the causes of anxiety. Similar to what was discussed for depression, different causes of increased anxiety could lead to different consequences for women's sexual desire. For example, if a woman's experience of anxiety is linked to problems with her current sexual partner, it's likely that thinking about sex would be associated with the cause of, rather than a solution to, anxiety. Therefore, she might want to avoid, rather than search for sex, to avoid feeling even more anxious. On the

other hand, if a woman's anxiety is related to stress for an upcoming exam session, her sexual desire might increase in response to the need of having a pleasurable space where she can feel good and relaxed, e.g., a safe anchor behavior.

The second possibility regards the individual's general level of sexual functioning. More than 30 years ago, in a review of the literature Barlow (1986) noted that individuals with a healthy sexual functioning, as compared to those who struggle with sexual dysfunctions, respond in opposite ways to the same moderate-to-high level of anxiety. Considered in the context of the present study, it could be hypothesized that the opposite effects found for women in the positive paradoxical vs negative paradoxical groups are associated with general levels of sexual functioning, with women in the negative paradoxical group having a poorer general level of sexual functioning compared to women in the positive paradoxical group. Although this does not provide a specific causal mechanism, it does provide a potential correlated construct that may help us explain these paradoxical effects, and that should be considered in future research.

***Within-Person Paradoxical Effects***

In the following section I address the two novel and inter-related findings that emerged in the present study: (1) the within-person paradoxical associations across the full range of negative mood symptoms, found for both depression and anxiety, and (2) the paradoxical effects found also at low levels of negative mood. It should be noted that the existence of the original paradoxical effect, as well as the newly found paradoxical effect at the low end of negative mood, are both driven by the existence of groups of women who show the within-person paradoxical associations. Therefore, the focus of the following discussion will be on why some women present a similar increase (or decrease) in sexual desire for both low and high levels of negative mood.

One possibility is that the same changes in sexual desire, under very different mood states, are driven by different mechanisms at the different extremes of mood. For example, high levels of desire associated with low levels of depression may best be conceptualized in terms of "celebratory" effects of positive mood/happiness. That is, it may be happiness, not low negative mood, that drives the increase in sexual desire when women report low levels of negative mood. For example, Bittoni et. al. (in preparation) found that day-to-day changes in happiness were significantly associated with day-to-day changes in sexual desire, even after controlling for the concurrent effects of depressed mood. On the other hand, an increase in sexual desire associated with high levels of depression for the same women, may be driven by a need for comfort and affection; thus, sex may become a strategy to deal with negative feelings and emotions (as suggested by Bancroft et al., 2003b). In these two examples there are different mechanisms used to explain the same outcome in sexual desire observed across different mood states: increased sexual desire as a consequence of celebration (e.g., a work promotion, an anniversary, or just to positively end the Saturday-night - see the "weekend effect" found in Roney & Simmons, 2013) vs. increased sexual desire as need for comfort (e.g., because you just had a fight with a friend, or a bad interview).

On the other hand, it is also possible that a single common mechanism can be used to explain similar changes in sexual desire across different extreme mood states. This idea is best captured by interactions/moderating effects. To incorporate this possibility, I propose that in addition to distinct mechanisms causing similar changes in sexual desire at the opposite extremes of mood (as discussed in the previous paragraph), in some cases there may be interactive effects involving negative mood and some moderator variable, thus providing a common mechanism for similar changes in sexual desire at the opposite extremes of mood. These potential moderating effects are the focus of the following paragraphs.

*Moderating Effects of Sensation Seeking.* One plausible common mechanism responsible for increased (or decreased) sexual desire at both extremes of depressed mood is sensation seeking. There are three mechanisms by which women high on sensation seeking might experience increased sexual desire for both high and low levels of negative mood. First, women may mislabel general arousal as sexual arousal, and because sensation seekers actively pursue intense emotions to increase their arousal, and would thus live in a state of increased general arousal, they will have more opportunities to misinterpret high levels of general arousal as sexual arousal (and because women tend to not distinguish between sexual arousal and sexual desire - Graham et al., 2004; Rosen et al., 2000 - they would be more likely to experience feelings of sexual arousal also as sexual desire). This mechanism may apply across diverse mood states. Specifically, when high sensation seeking women experience high or low levels of depression, they may pursue intense emotional experiences to either alleviate the depression or enhance the emotional experience of their low depression state, thus increasing their level of arousal, which could then be perceived as increased sexual desire., Alternatively, high sensation seekers might have learned to associate sex with inducing intense emotions and high general arousal, such that sex becomes one way of pursuing experiences leading to intense emotions, both in case of improving negative mood and increasing positive mood. Therefore, it could be expected that the association between negative mood and sexual desire, across the full range of mood, would depend on the individual's level of sensation seeking.

Previous research has examined this idea and has shown only weak associations between sensation seeking (primarily the disinhibition sub-scale) and the paradoxical effect of mood on sexuality (i.e., high scores on the Mood and Sexuality Questionnaire; or MSQ), for both heterosexual (Bancroft et al., 2003b) and gay men (Bancroft et al., 2003c). Yet, stronger associations have been found between sensation seeking (again, primarily the

disinhibition sub-scale), and risky sexual activity, for both heterosexual (Bancroft et al., 2004), and gay men (Bancroft et al., 2003a). However, because the current study and interpretations are focused on women's sexual desire rather than men's, and because the paradoxical effect in the current study was examined at both ends of the mood continuum rather than only the high end of negative mood, results could be significantly different, and thus future research should further test for these associations with women and considering the full range of mood symptoms.

*Moderating Effects of Erotophobia-Erotophilia.* An individual's position along the personality dimension of erotophobia-erotophilia (Fisher et al.,1988) could also moderate the association between mood and sexual desire, and thus provide a second common mechanism responsible for increased (or decreased) sexual desire at both extremes of negative mood. Erotophobia-erotophilia is a person's propensity to respond to sexual cues with either positive (approach) or negative (avoidance) affective evaluations and is proposed to develop primarily based on socialization (Fisher et. al., 1988). However, in addition to socialization, it is also likely that classical conditioning of associations between the individual's emotional and behavioral response (e.g., "I had sex when I was really anxious"), and the positive or negative outcome of that experience (e.g., "I felt relaxed" or "I felt even more anxious"), also contribute to this propensity. It could therefore be hypothesized that strong emotions may be associated with - and thus trigger for - either seeking out sex or avoiding sex, depending on past experiences of having sex in moments of high emotional states.

Note that, also based on learning and experience, and thus associated with an individual's position on the erotophobia-erotophilia continuum, are diverse cognitive coping strategies that could be adopted to respond to extreme mood states. Therefore, even the

subjective repertoire of sex-related coping strategies might play a role as moderator in the association between mood and sexual desire.

**Effects of the menstrual cycle**

Results obtained for the menstrual cycle indicate three main findings: 1) there are significant individual differences in mean levels of sexual desire experienced between women, independent from their menstrual cycle, which account for 21.5% of the variance in sexual desire; 2) an average effect of the menstrual cycle on female sexual desire can be described in terms of increased sexual desire around ovulation, although this explains only 1.6% of the variance in sexual desire; and 3) an additional 7.8% of the variance is accounted for by considering individual differences in the effect of the menstrual cycle on sexual desire. These results shed light on the discrepancies presented in Chapter 1, where I've discussed past theories and findings on the association between menstrual cycle and sexual desire.

The fact that people have different mean levels of sexual desire can be interpreted in the context of the Dual Control Model (Bancroft & Janssen, 2000). According to this model, individuals differ in terms of propensity for sexual excitation and sexual inhibition, which likely depends on hormonal, genetic and learning mechanisms, although the exact roles of these variables is not yet well understood.

To investigate the propensity for sexual excitation/inhibition, Janssen, Vorst, Finn & Bancroft (2002) built the Sexual Inhibition and Sexual Excitation Scales (SIS/SES), which was later modified and adapted by Graham and colleagues (2006) to women. Graham found that three factors were significantly related to sexual inhibitory mechanisms present in women. These factors were: concern about sexual functioning (e.g., concerning about "being a good lover"); arousal contingency (e.g., difficulties in becoming aroused); and relationship importance factor (e.g., importance of trusting the partner to have good sex). These factors

influence an individual's sexual experience and can be associated with negative emotional and/or sexual outcomes. For example, a woman worrying about not pleasing her partner (i.e., "being a good lover") can be less sexually satisfied (Dove & Wiederman, 2000). If this situation occurs repeatedly, it could create negative predictions about future sexual experiences, thus negatively affecting the woman's desire to have sex. The same reasoning can be applied to those factors associated with sexual excitation (i.e, setting, arousability, smell, partner characteristics, sexual power dynamics), which would instead positively affect sexual desire.

If we exclude the "smell" factor, all the above-mentioned factors involved in sexual excitation/inhibition operate through psychological mechanisms (e.g., "Someone doing something that shows he/she is intelligent turns me on."). One could therefore speculate that learning mechanisms and environment play a stronger role than genetic in shaping female sexual excitation/inhibition and desire. This speculation is supported by the fact that, contrary to what was initially hypothesized by Conaglen and Conaglen (2003), a higher average level of androgens was not found to be linked with higher levels of sexual desire in women. In addition, analyses presented by Roney and Simmons (2013) revealed no association between mean concentrations of progesterone, estradiol and testosterone with mean levels of sexual desire. Thus, overall, results suggest that psychological and/or affective factors strongly influence average levels of sexual desire, both in a negative and positive way, but the biological factors that have been tested do not show the same significant role. Thus, psychological factors could, at least partially, explain the individual differences found in mean levels of sexual desire across the women in the sample.

Although explaining only 1.6% of the variance in changes in sexual desire, a significant effect of the menstrual cycle was obtained. That is to say, overall women report an increase in sexual desire around the ovulation period. These results are in line with those

from previous studies linking oscillations in female sexual desire with fertility states (e.g., Stanislaw & Rice, 1988). However, given that menstrual cycle was found to differently affect sexual desire across women, accounting for 7.8% of the variance in sexual desire, talking about "average effects" does not accurately capture the complex relationship between menstrual cycle and sexual desire. In addition to different methodological choices and definitions adopted by the researchers in this field, this finding helps us understand why past studies didn't always confirmed a periovulatory peak in sexual desire (Bancroft et al., 1983). An online study I recently conducted on women confirms the presence of individual differences in the effect of the menstrual cycle on sexual desire (Bittoni & Kiesner, 2022). In particular, results indicate that among 785 women, 619 (79%) noticed changes in sexual desire across the menstrual cycle. Of these 619 women, an increase in sexual desire was reported by 143 women (23%) during menstruation; by 99 women (16%) the week *after* menstruation; by 212 women (34%) around ovulation and by 165 women (27%) the week *before* menstruation. The latest findings presented in this dissertation support the need of a new theoretical framework under which planning studies on the effect of menstrual cycle on sexual desire, which should include individual differences across women and the role of psychological factors. I believe that future research will benefit from these attempts to better understand the complexity of these associations, rather than research aiming at simplifying and decomposing them.

**Final Conclusions**

There are several important limitations of this study that should be noted. First, the current study did not consider the types of relationships the women were in (short-term, long-term, same sex, other sex, etc.), which could be an important moderator of the observed paradoxical associations. Second, I did not specifically examine coping strategies that individuals use to manage negative mood, nor did I measure personality traits or differences

in autonomic nervous system response. By directly assessing these variables, future research will hopefully be able to provide a better theoretical explanation of why women demonstrate such vastly different associations between negative mood and sexual desire. An additional aspect that may moderate the association between negative mood and sexual desire, that was not addressed in the present study, is whether the target of sexual desire is partnered or solitary sexual activity. Supporting this idea is research showing that depressed women, as compared to non-depressed women, report higher levels of desire for solitary sex, but not for partnered sex (see Frohlich & Meston, 2002).

Concerning the menstrual cycle's effect, it should be noted that no objective measures (e.g., blood sample or saliva sample) was collected to define the phases of the menstrual cycle. Thus, ovulation was assumed to occur halfway between the first and last day of the menstrual cycle.

These limitations acknowledged; the current study also provides important strengths. Specifically, the use of daily reports of both mood symptoms and sexual desire for two full menstrual cycles (approximately two full months), controlling for menstrual cycle-related changes in sexual desire, and using within-person random effects modeling, are all important methodological advancements in this area specifically, and in sexology more broadly. Indeed, I believe that the methods and analyses used in this study are unprecedented in this area, and given the high methodological quality of this study, that the results provide strong empirical support for the observed findings. I further suggest that one important strength of this study are the novel and compelling results that provide insights and new questions for future research.

The present study extended past research on the paradoxical associations between negative mood and sexual desire considering the full range of negative mood symptoms and using daily reports of all measures over two months of assessment. Important novel findings

showed that some women exhibit within-person paradoxical associations between negative mood and sexual desire across the full range of mood states, meaning they showed the same increase or decrease in sexual desire at both the high and low extremes of mood symptoms. My interpretation of these results suggests that causal mechanisms of sexual desire are very idiosyncratic, requiring in-depth assessment of multiple factors, such as causes of mood symptoms, personality, past learning, coping strategies, and types of sexual or romantic relationships, that may moderate the effects of mood on sexual desire. Although testing for possible moderators will be methodologically demanding, I believe that to better understand these paradoxical associations, and sexual desire more broadly, it is both possible and necessary. Indeed, discussing average effects of mood on sexual desire, while overlooking individual differences, might limit, rather than expand, our understanding of human sexuality. I therefore suggest that individual differences in sexual response and sexual functioning should be the focus of future research – not just when discussing single cases inside the clinical settings, but also in behavioral and cognitive research, to then provide better diagnosis and more accurate indications for both research and therapy.

Finally, through the use of mixed model analysis and the investigation of both fixed and random effects, I was able to test for both an average effect of the menstrual cycle on sexual desire and individual differences in that effect. As expected, the average effect was characterized by a small but significant negative cosine coefficient, indicating that on average there's an increase in sexual desire around ovulation. Nonetheless, results also showed that women differ greatly in that effect. These results provide a possible explanation of why past literature has found inconsistent results when investigating the (average) effect of the menstrual cycle on sexual desire. Future research should address individual differences not only when investigating the effect of psychological factors on sexual desire, but also when testing for biological (hormonal) influences.

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