



Review

The varied nature of women's sexuality: Unresolved issues and a theoretical approach

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ABSTRACT

During the 20th century there were clear indications that the socio-cultural suppression of women's sexuality had lessened, revealing a marked variability of women's sexual expression. In this article we review the recent literature to explore explanations for this variability. It is clear that we know little about the nature of sexual desire, and in particular, what it is that is desired. There is also now substantial evidence that vaginal response, as measured by vaginal pulse amplitude, is a relatively automatic response to perception of sexual stimuli, regardless of whether these stimuli are perceived positively or result in subjective arousal. This is considered as a possible mechanism that allows vaginal intercourse without pain, even when the woman is not sexually aroused. The roles of androgens and estrogen in women's sexuality remain uncertain. The evidence is, however, consistent with there being a testosterone-dependent component of women's sexuality that is more important for some women than others. Finally, a new theoretical model is presented that aims to resolve these uncertainties and that proposes different types of women's sexuality. Once we have a better understanding of "normal" female sexuality, in its various forms, our ability to develop effective treatments for women's sexual problems should improve.

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During the course of the 20th century there was increasing evidence of change in women's expression of their sexuality, both in terms of their age at first sexual experience, which became

progressively younger, associated with a substantial increase in premarital sexual intercourse, and in their increasing engagement in sex as a source of pleasure. We are now confronted with a considerable variability in women's experience of sexual activity and desire for sexual pleasure (Bancroft, 2009). A major change of this kind, which has happened fairly consistently across the Western world, and to a more variable extent in other cultures (Wellings et al., 2006), can only be explained by changes in socio-cultural control, and in this case, lessening of socio-cultural suppression of women's sexuality (Baumeister, 2000).

However, through most of the 20th century, relatively little attention was paid to the causes of sexual problems in women although, as we will see later, a number of studies explored the role of testosterone (T) in women's sexuality. Since the turn of the century, following the impact of Viagra and other phosphodiesterase-5 inhibitors on male erectile response, attempts have been made to find a "Viagra for women." The limited success so far may in part result from the lack of consideration of the marked variability in the non-problematic sexuality of women.

It will be difficult to establish a clinically useful conceptualization of women's sexual problems, and how they should best be treated, until we have a better understanding of the non-problematic variability of women's sexuality. There has now emerged a genuine interest among sex researchers to increase our understanding in that respect, and to move on from the preceding era in which women's sexuality and its problems tended to be conceptualized in the same way as for men. The aim of this paper is two-fold: first, to review the evidence of such variability, both across women and within women through their life span and second, to propose a theoretical approach to account for this variability, to promote further research to this approach, and to pave the way for the development of useful methods of treatment. The evidence considered will be mainly from the Western world. We will start with consideration of two concepts of central importance to our understanding of sexuality in both women and men: sexual arousal and sexual desire.

Sexual desire and sexual arousal

"Sexual desire" is an example of the somewhat arbitrary concepts we use to describe our experiences, reflecting the extent to which these concepts are socially rather than scientifically constructed. Earlier concepts like "libido" and "lust" have given way to "sexual desire." Sexual arousal is another concept that is more confined to scientific discourse, but is often used in ways that are not clearly defined. We are becoming increasingly aware of a gap between these concepts of sexual experience and how such experiences are manifested in terms of brain action and psychological processes, a challenge that has been particularly emphasized by the advent of functional brain imaging. Thus, among scholars of sexuality, sexual desire and sexual arousal have traditionally been seen as two relatively distinct though related phenomena. As evident in a recent review by Graham (2010a), whereas this distinction might have some validity when applied to men's sexual experiences, in studies of women's sexuality, there is consistent evidence that these two constructs are highly correlated (Nobre and Pinto-Gouveia, 2006; Rosen et al., 2000; Ter Kuile et al., 2006). In qualitative studies, a proportion of women have explicitly stated that they had difficulty differentiating "arousal" from "desire" (Brotto et al., 2009; Graham et al., 2004), although there was no indication that they considered this was a problem.

From our perspective, sexual desire and sexual arousal are overlapping concepts. Sexual arousal is a complex state that involves: (i) information processing of sexual stimuli, involving both automatic (or unconscious) and conscious cognitive mechanisms (Janssen et al., 2000); (ii) incentive motivation, which includes activation of the dopaminergic incentive motivational system involved in a variety of

appetitive behaviors; (iii) general arousal, or activation of the central arousal system involved in most arousal states (e.g., pleasurable excitement, fear or sexual excitement); and (iv) genital response. It is the "genital response" that is the most specifically sexual component of this state although, in the relevant context, the information processing will be focused on sexual stimuli (Bancroft, 2005). The interactions between these components are not well understood. The term "sexual desire" can be used to describe a state that has only some of these components (most often, relevant information processing and incentive motivation). The tendency for women to use these two concepts more interchangeably than men (Graham et al., 2004) may reflect their lesser awareness of genital response, which will be considered further below, and hence their greater emphasis on arousal in a more general sense (e.g., feeling excited).

In an early study of a representative sample of 225 40-year old Danish women, Garde and Lunde (1980) found that 30% of the participants described having little or no spontaneous sexual desire, yet most had no difficulty enjoying and becoming sexually aroused during sexual interaction with their partner. Over the last two decades, there has been much attention to possible gender differences in sexual desire (Baumeister et al., 2001) and in particular to the concept of "responsive" or "triggered" desire, with responsive desire considered more common in women than "spontaneous" desire (Basson, 2000). Basson (2000) proposed a model of female sexual response, whereby women most frequently engage in sexual activity not because of any intrinsic sexual desire, but from a state of "sexual neutrality," primarily motivated by non-sexual reasons, such as desire for emotional closeness with a partner. There is some evidence that this model may be more applicable to women with sexual problems than those without sexual problems (Sand and Fisher, 2007). Relevant to this issue is the incentive motivation model (ICM) (Both et al., 2007), which sees sexual desire as resulting from awareness of sexual arousal or excitement that has already occurred in response to a sexual stimulus, even when the woman is unaware of encountering the stimulus. Both sexual arousal and sexual desire are perceived in this model as responses to a sexually relevant stimulus; internal thoughts or fantasies are considered equivalent to external sexual stimuli in this context. Proponents of the ICM argue that there is no such thing as "spontaneous sexual desire" (Laan and Both, 2008) because "in order for the sexual system to be activated, the brain has to have processed sexual information" (p. 511). These researchers acknowledge that sexual desire may "feel" spontaneous, but that this is because sexual stimuli are often processed outside of our awareness (Spiering et al., 2006).

We would suggest that for most women, such as those in Garde and Lunde's (1980) study, spontaneous sexual desire would mean desire being experienced not as a response to external cues, but as a result of them thinking about sex and finding the thoughts motivating. This can be contrasted with the situation where a woman thinks about her sexual partner, or even sexual interaction with that partner, without experiencing any desire; the thought just passes through her mind without initiating a state of "desire."

Looked at in this way, we need to consider what determines whether such a thought does or does not have an activating effect. This may not depend on the stimulus, but on the individual's state of responsiveness at that point in time. This is the distinction that Whalen (1966) made between "arousal" and "arousability." Various factors, independent of external stimuli, can influence an individual's arousability i.e. their disposition to respond to sexual cues (Laan and Both, 2008), including hormonal factors. An example is the effect of testosterone on a man's arousability; in a hypogonadal state he is markedly less responsive to sexual stimuli. However, in general, and particularly in the case of women, we understand little about the determinants of sexual arousability. Returning to Garde and Lunde's sample, while 30% of their female participants were not responding to their own thoughts, they were presumably responding to sexual

interaction initiated by their partner, eventually if not immediately. This probably involves different determinants of arousability than is the case when responding to thoughts or fantasies. This confronts us with the possibility that women may vary in the pattern of development of arousal they typically experience in a sexual context, and this may be a key factor in the variability of women's sexuality that we are striving to understand.

The nature of sexual desire—desire for what?

In her recent review on Hypoactive Sexual Desire Disorder, [Brotto \(2010\)](#) highlighted the extent to which the concept of women's sexual desire has been assessed much as it would be for men, with little or no consideration of how it might be different for women, and furthermore, how it might differ between women.

[Meana \(2010\)](#), in a comprehensive review of the literature on women's sexual desire, focused on how little we understand about what is desired. This revealed a striking gap in our understanding of the concept. The term has been used widely without any explicit consideration of what is desired. The implicit assumption is that it is desire for sexual activity or sexual pleasure. But, as Meana pointed out, this assumption does not reflect the evidence to date, which suggests that women who feel sexual desire do not always want to have sex. She made a distinction between “desire to be desired,” which does not necessitate sexual interaction (being desired may be rewarding in itself) and “desire to have sex.” Regarding “desire to be desired,” although there is little direct evidence supporting this, qualitative data indicating that many women report that “feeling desired” enhances their arousal would be consistent with this ([Brotto et al., 2009](#); [Graham et al., 2004](#)). In the latter case, there may be various reasons for wanting to have sex; they may be relational in a relatively non-sexual way (e.g., when sexual intercourse provides emotional contact) ([Impett and Peplau, 2002](#); [Meston and Buss, 2007](#)). And, more in line with men's sexual desire, there may be desire for sexual pleasure and perhaps orgasm. Finally, Meana questioned whether, for some women, the experience of sexual desire is in itself rewarding without any translation into sexual action. We are only just starting to explore these fundamental aspects of women's sexuality.

These issues have implications for how we assess sexual desire in women. To assess sexual interest, researchers have most often asked women about the frequency of sexual thoughts and indeed this is what we have done in our own research, using the Interviewer Ratings of Sexual Function (IRSF; [Graham et al., 1995](#); [Tyrer et al., 1983](#)) or daily diaries. In interviewing women about the frequency of sexual thoughts, across a number of studies involving participants of different age groups, two things have been apparent. Firstly, when asked about the frequency of thinking about sex with interest or desire (from “rarely or never” to “at least once a day”), the variability among women is very evident. For example, in a national survey of women in heterosexual relationships ([Bancroft et al., 2003a](#)), for the past month, 14% answered “daily,” 26% “several times a week,” 31% “once a week,” 21.8% “once or twice,” and 7.2% “never.” Secondly, we have observed a tendency for some women to have difficulty answering the question, even when we carefully define what we mean by sexual interest (e.g., “Apart from the times that your partner approached you wanting to make love, how often have you found yourself thinking about sex with interest or desire? This includes times of just interest, daydreaming, and fantasizing, as well as times of lovemaking”). In a recent qualitative study, [Brotto et al. \(2009\)](#) found that approximately one third of their subjects expressed difficulties in “putting words to how they understand desire” (p. 6).

Genital response in women

As proposed earlier, genital response is the most specifically sexual component of the complex pattern of sexual arousal. Here, in making

comparisons with male sexual response, we need to distinguish between tumescence of the clitoris and labia, which can be regarded as homologous to penile erection in the male, and vaginal response, involving increased blood flow in the vaginal wall and an associated transudation of vaginal fluid. This, together with the changes that occur in the uterus and the pelvic floor, are unique to the female. Research into genital response in women has predominantly involved measurement of vaginal blood flow or vaginal pulse amplitude (VPA). Measurement of clitoral or labial tumescence has received much less attention. In the 1980s a labial clip to measure skin temperature was used in a number of studies, but then went out of favor. Recent studies by [Kukkonen and colleagues \(2007, 2010\)](#) have revived this approach using the new technology of thermography and suggested that temperature change specific to the labia was significantly correlated with subjective sexual arousal in women. In addition, a limited amount of research using MRI scanning of the female genitalia during response to sexual stimuli has been reported (reviewed by [Heiman and Maravilla, 2007](#)).

However, the relationship between the uniquely female vaginal response and sexual arousal confronts us with possibly the most striking challenge in this field. It has been widely assumed that vaginal lubrication is the female version of genital response; in fact it is frequently described as “genital arousal.” The sole requirement for a DSM-IV diagnosis of “female sexual arousal disorder” ([American Psychiatric Association, 2000](#)) is the lack of “an adequate lubrication-swelling response”; no definition of an “adequate lubrication-swelling response” is given, and no mention of lack of subjective excitement or arousal is included in the diagnostic criteria. Many researchers have questioned the nature of the relationship between vaginal lubrication and sexual arousal ([Laan and Everaerd, 1995](#); [Levin, 2003](#)) and women themselves often describe a poor correlation between the two ([Graham et al., 2004](#)).

Rather than measuring vaginal lubrication or swelling, however, since the beginning of modern sexual psychophysiology in the 1970s, the most common method of measuring genital response in women has been vaginal pulse amplitude (VPA), measured by a photometer placed in a tampon-shaped device that fits easily and unobtrusively into the vagina. Increase in VPA is interpreted as an increase in vaginal blood flow (VBF) that underlies the vaginal transudation response that results in lubrication. However, it has become increasingly apparent that whereas there is a predictable increase in VPA in response to a sexual stimulus, this is poorly correlated with the woman's subjective awareness of sexual arousal ([Everaerd et al., 2000](#); [Laan and Everaerd, 1995](#)). This contrasts with the measure of penile erection in men that correlates well with subjective ratings of sexual arousal ([Chivers et al., 2010](#)). This discordance between vaginal response and subjective arousal in women is compounded by the fact that VPA tends to increase with any stimulus which has clear sexual connotations, whether or not the woman finds the stimulus appealing, and even when she has a negative reaction to it ([Laan and Both, 2008](#); [Laan and Everaerd, 1995](#)). This led [Laan and Everaerd \(1995\)](#) to speculate whether increased VBF was an “automatic response mechanism.” Laan and her colleagues have documented that this automatic response to sexual stimuli, such as an erotic film, occurs in women of different ages (both pre- and post-menopausal) ([Laan et al., 2002](#)), in women with deficient levels of testosterone ([Tuiten et al., 1996](#)), and in situations where women report disliking the erotic film and having no subjective arousal ([Laan and Everaerd, 1995](#)). Vaginal response can even occur during non-consensual sexual activity ([Levin and van Berlo, 2004](#)). Further evidence of this discordance is found in the few laboratory studies that have assessed the effects of phosphodiesterase-5 inhibitors, such as sildenafil, on sexual response in women with sexual arousal problems. These have shown an increase in VPA in the absence of any increase in subjective sexual arousal ([Chivers and Rosen, 2010](#)). There is nothing comparable to this response in the male.

Recently, Chivers et al. (2010) carried out a meta-analysis of 132 laboratory studies (involving 2505 women and 1918 men) reporting correlations between self-reported and genital measures of sexual arousal, which in men were based on measuring increase in penile circumference, and in women on increase in VPA. For men the meta-analytic correlation was $r = 0.66$, and for women $r = 0.26$, a significant difference. A number of possible explanations have been put forward to explain this lack of “concordance” between genital and subjective arousal in women compared with men e.g., men being more aware of their genital response than women (Chivers et al., 2010). However, the bigger challenge is to explain why women have an automatic vaginal response to sexual stimuli, regardless of whether they find the stimuli appealing, and this has received much less attention than the “discordance” aspect.

Laan and Everaerd (1995) made some attempt to explain this paradox, suggesting that an automatic genital response to sexual stimuli might be adaptive, stating, “If genital responding to sexual stimuli did not occur, our species would not survive” (p. 68). However, they went on to comment that this mechanism appears to override the effects of voluntary control. It is difficult to reconcile that idea with the widespread assumption that women need inhibitory mechanisms to keep them out of sexual trouble (Bjorklund and Kipp, 1996). Chivers et al. (2010) put forward a slightly different suggestion, pointing to the evidence that at least some women experience vaginal response during sexual assault (Levin and van Berlo, 2004). This led them to postulate that “the reflexive activation of vaginal responding to sexual cues may serve a protective function for women...Ancestral women who did not show an automatic vaginal response...may have been more likely to experience injuries that resulted in illness, infertility or even death subsequent to unexpected or unwanted vaginal penetration, and thus would have been less likely to have passed on this trait (*or lack of it*) to their offspring” (p. 46; italics added). It seems, however, improbable that this complex reflex response pattern, together with the specialized pain reduction mechanisms elicited by vaginal or cervical stimulation (Komisaruk and Whipple, 1995), would have evolved primarily to protect women from the injuries of unwanted sex. It seems more likely that this evolved to allow women to have vaginal intercourse without pain.

Developmental aspects of genital response

This confronts us with a major lack of understanding of this aspect of women's sexual function. How does this automatic avoidance of pain from vaginal intercourse relate to the early coital experiences of young women? It may be helpful to consider the typical experiences of young women when first engaging in vaginal intercourse. The age of first coitus has decreased in recent years (e.g., Stigum et al., 2010). To what extent is the adolescent approaching sexual intercourse for the first time aroused in the same way as she would typically be at a later age, or after being in an established relationship, which has allowed her to learn how best to engage in this experience?

Until recently, the available evidence has mainly been from adult women, the majority students, recalling their first coital experience. For example, in a Canadian study (Tsui and Nicoladis, 2004), female students (mean age 19 years) recalled their first coital experience, which occurred at a mean age of 17 years. Although 61% rated this first experience as positive overall, only 34% were physically satisfied, 12% experienced an orgasm, and 52% experienced pain. No questions were asked about vaginal lubrication, so it is not clear to what extent the pain was due to inadequate lubrication or to hymeneal rupture. In more recent studies of adolescent females, the focus has been on early sexual experiences rather than specifically the first episode. In another Canadian study (Landry and Bergeron, 2009), questionnaire data was obtained from 1425 12 to 19 year old schoolgirls (mean age 15 years). In a sub-group of 251 girls who had experienced sexual

intercourse at least five times, 20% reported pain during intercourse at least 75% of the time, and for at least 6 months. When asked to indicate from a diagram where they experienced the pain, significantly more girls indicated the vaginal opening than the internal vagina or lower abdominal region. An interesting association was also found between dyspareunia and pain on tampon insertion; experiencing pain at first tampon insertion was linked to a fourfold increase in subsequent reporting of chronic dyspareunia. Here again, we have no information about problems with vaginal lubrication.

In a national survey of young people up to the age of 25 in the Netherlands (De Graaf et al., in press; cited in Van Lunsen et al., in press), the prevalence of sexual problems, particularly in girls, was high. For 57% of the girls, sexual intercourse was often or always painful. In a recent U.S. national survey that included 820 14–17 year old adolescents, 242 (114 males and 128 females) reported at least one partnered sexual act in the past year (Fortenberry et al., submitted for publication). About 25% of the young women reported some difficulty with vaginal lubrication, and this was significantly more likely in the 14 year olds (33.3%). Pain during the most recent sexual event was reported by 52% of the females, and this was also significantly more likely in the younger females. Sexual arousal was reported as significantly higher in the older than the younger females.

It remains uncertain at what stage in a woman's sexual development the automatic vaginal lubrication and the associated reflexive pain threshold elevation, are established. The evidence so far indicates that pain during vaginal intercourse is common among adolescent women. But it is not yet clear to what extent such pain results from insufficient vaginal lubrication, or is the result of vulvar hypersensitivity. Research is required to focus on these issues. It remains a possibility, however, that the existence of an automatic genital response pattern of this kind, once established, means that women can engage in vaginal intercourse for reasons other than obtaining sexual pleasure e.g., to give their partner pleasure, feel close to their partner, or get pregnant, and this may become more relevant when they have gained some experience of sexual interaction. This is a potentially important aspect of sexual variability in women, to which we will return later.

Orgasm in women

The reproductive importance of orgasm in men is obvious because of its association with ejaculation and the motivating effect of the pleasure of orgasm. In women, the role of orgasm is less clear and women vary in their capacity for orgasm and in the frequency with which they experience it (Graham, 2010b). This is therefore a key factor in the variability of women's sexuality.

In the Global Survey of Sexual Attitudes and Behaviors (Laumann et al., 2005), that used computer-assisted telephone interviewing and postal questionnaires to assess sexual problems in 9000 women aged 40–80 years, the prevalence of “inability to reach orgasm” ranged from 17.7% (in Northern Europe) to 41.2% (in Southeast Asia). Kinsey et al. (1953) found that 9% of women reported having been unable to ever experience orgasm. Lloyd (2005), in her book on female orgasm, included a table on orgasm rates during coitus obtained across a number of studies; the percentage for women who reported “always” or “almost always” experiencing orgasm during coitus ranged from 12% to 59%.

Women also vary considerably in the age at which they first experience orgasm. Kinsey et al. (1953) found that 23% had experienced orgasm by the age of 15, 53% by age 20, 77% by age 25, and 90% by age 35. There has probably been some shift towards earlier first experience of orgasm since then, because of the lessening of socio-cultural suppression of women's sexual pleasure (Baumeister, 2000). This point will be considered further in the next section on masturbation.

In the U.S. National Health and Social Life Survey (NHLS), Laumann et al. (1994) reported that, during the previous year, 29% of women always experienced orgasm during sexual activity with their partner. Women's rates of orgasm consistency (defined as "usually or always" experiencing orgasm) were higher during masturbation than during sexual activity with a partner. About 60 percent of women reported that they "usually" or "always" had an orgasm when masturbating, compared with 29 percent during partnered sex (the corresponding figures for men were 80% and 75%).

This reflects considerable variation in the ease with which women achieve orgasm. Some women can experience orgasm from fantasy alone, or from breast stimulation or stimulation of other non-genital areas. Other women require specific forms of genital stimulation. In some women this requires direct stimulation of the clitoris, in others, stimulation of the anterior vaginal wall, leading Freud to postulate that there were clitoral and vaginal orgasms, the first being an immature form. This generated a lot of controversy before being refuted first by Kinsey et al. (1953), and later by Masters and Johnson (1966). The idea that there are different types of orgasm has persisted, however; Singer (1973) proposed that there were two types, which he called "vulval" and "uterine," reflecting the patterns of sensation experienced during the orgasm (for review, see Mah and Binik, 2001). There is now good evidence that many women require clitoral stimulation to reach orgasm, and although the proportion that report that they always experience orgasm during intercourse varies across studies, it is usually a minority (Lloyd, 2005). We should keep in mind, when striving to understand the function of women's orgasm, that women are not anatomically constructed to receive clitoral stimulation during vaginal intercourse.

The issue of the female orgasm has therefore generated a considerable amount of debate and controversy over the years. Another debate has been whether female orgasm has any reproductive relevance. There are some who have argued that orgasm enhances fertilization, and that it is, as such, an evolutionary adaptation (e.g., Baker and Bellis, 1993). Lloyd (2005) wrote a critique of this literature and made the convincing case that these proposals of "adaptation" were all examples of "bias in the science of evolution." She concluded by supporting Symons's (1979) "by-product" explanation i.e. orgasm is a response pattern necessary in the male for reproduction, but remaining as a potential response in women because there had been no evolutionary reason to suppress it. We will return to this "by-product" concept below. Further evidence to support Lloyd's position comes from a classical twin study by Dunn et al. (2005) that investigated orgasmic responsiveness in 4037 women. Comparison of identical and non-identical twin pairs showed an estimated heritability of 34% for difficulty reaching orgasm during intercourse and 45% for difficulty reaching orgasm during masturbation. Two additional studies have explored the role of genetic influences on variability in female orgasmic function in non-clinical samples of women (Dawood et al., 2005; Harris et al., 2008). Dawood et al. (2005) reported that genetic influences accounted for approximately 31% of the variance of frequency of orgasm during sexual intercourse, and 51% of the variance of frequency of orgasm during masturbation. More recently, Harris et al. (2008) investigated personality factors and their associations with female coital "orgasmic infrequency" in a sample of 2632 women from the same UK twin register. Introversion, emotional instability, and "not being open to new experiences" were associated with orgasmic infrequency. While these results are intriguing, the authors themselves acknowledged that their assessment of orgasm was quite limited and these studies require replication. However, the results point to a definite genetic influence in some important aspects of orgasmic potential. Such genetic variability would not be likely to occur if orgasm was important for female fertility.

Levin (2005) proposed that it is sexual arousal that is most important for conception, with its vaginal tenting and pooling of semen providing the optimum environment for the capacitation of sperm. Orgasm, in contrast, is likely to prematurely terminate this environment. Overall, there is no evidence that orgasm in women has

any enhancing effect on women's fertility. The question of whether women who are unable to experience orgasm are less fertile than orgasmic women has not yet been studied.

Masturbation

Masturbation by women is of particular relevance to this article because it involves self-stimulation for sexual pleasure, with no involvement of a partner. It is also a behavior that has been severely stigmatized in the past. As part of the general lessening of socio-cultural suppression of women's sexual pleasure, there has, not surprisingly, been an increase in the proportion of women who masturbate. In the Kinsey data, from the 1940s and 1950s (Gebhard and Johnson, 1979), 95% of men and 40% of women had masturbated at some time in their life. In the British National Survey of Sexual Attitudes and Lifestyles (NATSAL 2000–2001) survey, the comparable figures were 94.6% of men and 71.2% of women; in addition, 73.0% of the men and 36.8% of the women had masturbated in the previous four weeks (Gerressu et al., 2008). This highly significant gender difference is consistent across studies (Petersen and Hyde, 2010). In the NHLS (Laumann et al., 1994), 63% of men and 42% of women had masturbated during the previous year, with 27% of men and 8% of women indicating that they did so at least once a week. In the Sex in Australia survey (Richters et al., 2003), 65% of men and 35% of women reported masturbating during the previous year.

Bancroft et al. (2003b) compared a sample of university students with an age-matched sample of students from the original Kinsey dataset obtained 50 years earlier. In the more recent sample, 83% of the women had masturbated at some stage in their lives, compared to 38.6% of the sample from the earlier Kinsey et al. (1953) study. The age of onset of masturbation, however, showed a very similar pattern in the two samples, with a striking gender difference between the men and women. For men, there was little difference in the proportion who had masturbated across the two studies (98% in the recent sample and 95% in the earlier sample) and there was a close association between onset of puberty and onset of masturbation, with the latter occurring within 2 years either side of the age at puberty. In women, the age of onset of masturbation was much more variable and, on average, the onset was 2 years earlier than for the men. In the recent sample, around half of the women who had masturbated had started before puberty, and in the earlier Kinsey sample, a third had done so.

These data suggest that masturbation, free from all the complexities of relational sex, can be a useful marker of certain aspects of women's sexuality, particularly the desire for sexual pleasure and orgasm. In support of this, the NATSAL study discussed above (Gerressu et al., 2008) reported a gender difference in the relationship between frequency of masturbation and frequency of partnered sexual activity. For women, masturbation was more likely among those who reported more frequent vaginal sex in the last four weeks, a greater repertoire of sexual activity (such as reporting oral and anal sex), and more sexual partners in the last year. In contrast, the prevalence of masturbation was lower among men reporting more frequent vaginal sex. The authors concluded that masturbation for many predominantly heterosexual men may represent a substitute for vaginal sex, while for women the practice appears to be part of the wider repertoire of sexual fulfillment, supplementing, rather than compensating for, partnered sex.

In the Bancroft et al. (2003b) study on the age of onset of masturbation, we saw how this particular pattern of female sexuality can emerge well before puberty. It is possible that this reflects hormonal effects of androgens; those girls starting to masturbate before puberty may be very sensitive to androgens, which increase at adrenarche (i.e., the increase in androgen production from the adrenal cortex, around the age of 8) (McClintock and Herdt, 1996). Women more moderately sensitive to androgens may react to the more substantial increases associated with puberty. Those who are not

androgen sensitive may start their masturbatory exploration of sexual pleasure well after the onset of puberty.

The relevance of hormones to women's sexuality

Whereas we have a reasonably clear picture of the hormonal determinants of male sexuality, with women the picture is far from clear. It is, however, distinctly possible that part of the variability of women's sexuality is determined hormonally.

First, we have to consider the impact of the menstrual cycle. This is a complex cyclical pattern involving the follicular phase, which encompasses approximately the first half of a typical cycle, and leads to ovulation and the consequent initiation of the luteal phase. Estradiol (E), the principal estrogen, rises steadily during the follicular phase until it triggers the increased release of luteinizing hormone (LH) from the pituitary, as a result of a specialized positive feedback response to the E rise. The LH peak results in rupture of an ovarian follicle and consequent ovulation. This is followed by a further increase in E together with progesterone (P), characterizing the luteal phase. If conception does not occur, both E and P decline, leading to menstruation, followed by the start of the next cycle. It is not clear what happens to testosterone (T) during the early cycles of post-menarcheal adolescents, but once the menstrual cycle settles into a regular ovulatory pattern, T increases during the follicular phase, and is maximal around the mid-third of the cycle before declining in the final third to reach a nadir during the first 2 or 3 days of the next follicular phase. There is a substantial literature on the pattern of sexual interest and activity across the menstrual cycle, although the evidence is inconsistent (Hedricks, 1994). One relatively consistent finding is that sexual activity is lowest during the menstrual phase, but obviously there are non-hormonal explanations for this; menstrual pain may be a factor, and the woman and/or her partner may be reluctant to engage in vaginal intercourse while there is vaginal bleeding. Sexual activity is also more likely to be partner-determined than sexual interest. Regarding sexual interest, there is a tendency across studies for sexual interest to be highest during the follicular phase or around ovulation (Wallen, 1995), but with considerable individual variability in this respect (see, for example, Diamond and Wallen, 2010). It is not clear to what extent such cyclical patterns of sexual interest are related to cyclical changes in E or T.

In women, T is produced mainly by the interstitial cells of the ovary. Androstenedione (A) is produced by both the ovary and the adrenal cortex and can be converted into either T or E. Dehydroepiandrosterone (DHEA), an androgen produced by the adrenal cortex, is present in the circulation in large amounts, even larger in its sulphate form (DHEA-S), which is regarded as its storage mode. DHEA can be converted into A, and hence also into T or E. In addition, DHEA is one of the recently discovered neurosteroids (Yen, 2004), which means that it can be synthesized within the brain and then converted into T or E within brain cells, presenting us with neurosteroid mechanisms that are independent of the steroid hormones in the circulation. As yet, however, there is no clear evidence that DHEA as a neurosteroid has any direct effect on women's sexuality, although there may be indirect effects via its involvement in improving negative mood (King, 2008). This is an aspect of reproductive endocrinology that as yet is very little understood.

In this paper we will restrict our attention to the possible relevance of E and T. We will first consider T, which, somewhat paradoxically, has received much more attention in the literature on women's sexuality than has E.

Testosterone

This specific aspect of behavioral endocrinology has been limited by the difficulties in attaining reliable measures of serum testosterone,

particularly in its free, unbound form. In the more recent literature, appropriate attention has been paid to this issue.

There are three ways that the role of T in women's sexuality has been explored: (i) looking at correlations between endogenous androgen levels in the plasma and measures of sexuality; (ii) examining the effects of iatrogenically lowered plasma T; and (iii) evaluating the effects of administering exogenous T. The results of these three approaches will be briefly summarized (for a more comprehensive review, see Bancroft, 2009).

Endogenous androgen levels

The most substantial study in this category was reported by Davis et al. (2005). In a community sample of 1021 Australian women, aged 18–75 years, each woman completed the Profile of Female Sexual Function (PFSF; Derogatis et al., 2004) and had one fasting morning blood sample taken, which for pre-menopausal women was collected between the eighth day of the menstrual cycle and the start of the next cycle. This was assayed for total and free T, A, and DHEA-S. The seven domain scores from the PFSF (sexual desire, arousal, orgasm, sexual pleasure, sexual concerns, sexual responsiveness, and sexual self-image) were not normally distributed, and because of age differences in these scores, the sample was divided into two age groups (“younger,” 18–44 years, and “older,” 45–75 years). For each PFSF domain, each age group was divided into low scorers and the remainder (high scores indicated better sexual function); for the younger group, the low scorers were the lowest 5% and for the older group, those who scored zero. No significant relationships between having a low score for any PFSF domain and having a low serum total or free T or A level were demonstrated. Lower DHEA-S, however, was significantly associated with lower scores in some domains (in the younger group, the desire, arousal and responsiveness domains, and in the older group, the arousal, responsiveness, and pleasure domains). Although this is by far the largest study of this kind, it has a number of limitations. The wide window of the menstrual cycle in which blood samples were obtained would add noise to the data. The highly skewed distribution of the main sexuality measure, resulting in a clear “problem” group, is another limitation. In one early study comparing 20 women using oral contraceptives (OCs) complaining of sexual problems with 20 matched pill-users without sexual problems (Bancroft et al., 1980), correlations between T and measures of sexuality were higher in the non-problem group. This raised the possibility that, whether or not the low T is relevant, the development in the woman's mind that she has a sexual problem, and the repercussions of this in her sexual relationship may well obscure subtle hormone-behavior relationships. Future studies would be improved by using a measure of sexuality with a more normal distribution in non-clinical samples.

The study on which the Davis et al. (2005) paper was based is one of several which found an association between hormone levels and mood or well-being in women. This finding was reported in a separate paper (Bell et al., 2005), and any attempt to see if lower sexual functioning in these women could be secondary to negative mood changes has not been reported by these authors. Given the major importance of mental health to sexual well-being in women, this was an important omission. This is exemplified in a study of 141 women aged 40–60 years (Cawood and Bancroft, 1996), in which no direct associations between measures of sexuality and T, A, DHEA, or DHEA-S were found. The best predictors of the quality of sexual life were the quality of the relationship and the woman's state of well-being; DHEA was a significant predictor of well-being.

Iatrogenic lowering of T

The two most common medical procedures that lower plasma T are (i) use of OCs, and (ii) bilateral ovariectomy.

There is now consistent evidence that OCs substantially reduce plasma T levels (Coenen et al., 1996), and as OCs are also likely to

increase plasma levels of sex hormone binding globulin (SHBG), the reduction will be more marked for free T than total T. This therefore provides us with a potentially informative model for exploring the role of T in women's sexuality, although one that has been little used. However, we have some limited evidence.

In a placebo-controlled study of women, all of whom had either been sterilized (by tubal ligation or laparoscopic tubal occlusion), or their partners vasectomized, administration of a combined OC (Microgynon) resulted in significant lowering of sexual interest (Graham et al., 1995). In a later Kinsey Institute study of women starting on OCs, sexuality and mood were assessed at baseline, and then at 3, 6, and 12 months (or until the OC was discontinued). The three strongest predictors of discontinuation were measures of sexual interest (frequency of sexual thoughts), sexual arousability, and reported emotional side effects (Sanders et al., 2001). Only one small study ($N=61$) to date has measured plasma T as well as sexual interest and responsiveness before starting on OCs, and repeated these assessments after initiation of OC use (Graham et al., 2007). Although the expected reduction in plasma T, and particularly free T, was highly significant, the association between T levels and sexuality measures showed no clear pattern. After 3 months on OC, the reduction in free T was significantly correlated with the frequency of sexual thoughts ($r=0.36$, $p=0.006$) and percentage of occasions of sexual activity when sexually aroused ($r=0.28$, $p=0.03$). However, when the sample was divided into three equal-sized groups based on the level of free T, 75% of the low free T group reported sexual thoughts "several times a week" or "daily." It was therefore clear that a majority of women experienced substantial reduction in their T levels with no adverse effect on their sexual desire. There are two plausible explanations for this. First, there may be a sub-group of women who are dependent on T for their sexual interest and arousability (as men are), whereas other women are not dependent on T in this way. Second, women may vary in sensitivity to T so that those with lower sensitivity need higher levels of T, and are more readily affected by T reduction. Those with high sensitivity, on the other hand, might still have enough T after its OC-induced reduction. As yet we cannot say which, if either, explanation is correct. It is noteworthy, however, that the only studies that have shown correlations between T levels and sexual interest in women have involved women on OCs (Alexander and Sherwin, 1993; Bancroft et al., 1980, 1991). This led Alexander and Sherwin (1993) to postulate that there is a threshold for T effects on sexuality, much as there is in men but at a very much lower level. According to this hypothesis, as in men, correlations between T and sexual interest in women would only become significant when levels are close to this threshold and this may only happen when the T levels are in the lower part of the normal range, as with OCs.

A further important point about this literature is that those women whose sexuality is negatively affected by OCs are likely to discontinue pill use. Thus, cross-sectional samples of OC users are unlikely to include women with T-dependent sexuality. Few of the recent cross-sectional studies in this area acknowledge this limitation (e.g., Wallwiener et al., 2010).

Surgical removal of the ovaries in both pre- and post-menopausal women is another treatment that results in a substantial reduction in circulating androgens. This raises the question of how many women who have undergone this procedure experience reduction in sexual interest. In several respects this is a difficult question to answer, as bilateral ovariectomy is usually combined with hysterectomy, and is most often carried out to treat some significant health problem, such as menorrhagia or pain; the surgery therefore typically results in considerable symptom improvement. Hence, this confounds the pre-operative state as a baseline for evaluating change, and no studies of this kind have attempted to establish a baseline for sexual health before the onset of the gynecological symptoms. Nathorst-Böös et al. (1993a) compared women who had bilateral ovariectomy and hysterectomy with two groups of age-matched hysterectomized

women, one having undergone ovariectomy plus E replacement, the other hysterectomy alone ($n=33$ in each group). In addition to questionnaire assessment of current status, each woman was interviewed and asked about how her sexuality had changed since the surgery. This assessment was from 2 to 6 years following the surgery. Few differences were found between the ovariectomized women with and without E replacement, and approximately 50% of each group reported a decrease in sexual interest. In the hysterectomy-only group, only 18% reported a decrease in sexual interest post-operatively (Nathorst-Böös et al., 1993a). A possible explanation is that the ovariectomy countered the beneficial health effects of the hysterectomy in some women, and this adverse consequence of ovariectomy was not offset by E replacement, and may have depended in part on reduction in T.

Another factor to be considered in interpreting such evidence is that women are not randomly assigned to have hysterectomy with or without ovariectomy; they make the choice themselves after being informed of the advantages and disadvantages of each alternative by their surgeon. Aziz et al. (2005a) compared 217 women who chose hysterectomy only (H only), with 106 women who chose hysterectomy plus ovariectomy (HO). They assessed all women preoperatively; compared to the H only group, they found that the HO group were significantly more anxiety-prone, as assessed by the Karolinska Personality Scale, and scored lower on six of the ten items in the McCoy Female Sexuality Scale (sexual satisfaction, sexual enjoyment, sexual arousal, frequency of orgasm, sexual relationship with partner, and coital frequency). At baseline the HO group also reported more menopausal symptoms (e.g., hot flashes, headache, irritability and depressed mood) and was more likely to have used hormone replacement therapy pre-surgery than the H group. In a separate paper (Aziz et al., 2005b), the post-operative outcome was reported. Estrogen replacement was recommended for all women in the HO group and for those in the H group with menopausal symptoms. At one-year follow-up, the HO group showed no change in the sexuality measures, whereas the H only showed a significant worsening in two of the scale items (sexual enjoyment and coital frequency) and the total score, presumably reflecting their greater scope for change. The two groups did not differ significantly in the pre-post change scores. Both groups showed improvement in well-being, and there were no correlations between the pre- to post-operative change in androgen levels (T, A, and DHEA-S) and changes in any aspect of well-being or sexuality.

In a prospective study, Farquhar et al. (2002) compared 57 women who had hysterectomy with ovariectomy (HO) with 266 women who had hysterectomy (H only). They found no deterioration sexually in either group at 6 months post-surgery. However, the H only group reported a significant increase in sexual interest and frequency of sexual intercourse, presumably reflecting the health benefits of the surgery. The HO group showed no such benefits. At 3 years follow-up, this post-operative difference, in terms of frequency of sexual intercourse, was maintained (Farquhar et al., 2006). A number of other relevant studies have been reported and were reviewed by Bancroft (2009).

Overall, these findings do not give us a clear answer regarding the relationship between post-ovariectomy hormonal change and sexual interest. However, one reasonable conclusion is that a substantial proportion of women can experience the major reduction in T following ovariectomy without any decline in sexual interest, and those that show a decline may be women whose sexuality is more T dependent.

Administration of exogenous T

The use of T administration for the treatment of pre-menopausal women with low sexual desire was assessed using placebo control in a double-blind cross-over study by Goldstat et al. (2003). T

administration resulted in significant improvements in measures of sexuality and general well-being.

In a parallel group design study involving post-menopausal women with low sexual desire, transdermal T administration (300 µg) was compared with placebo (Shifren et al., 2006). There were significant benefits from T administration and in addition, modest but significant correlations were found between the increase in free T and improvements in several aspects of sexual function. This study differed from most of the previous studies involving T administration, by producing T levels within the normal physiological range. Other earlier studies, mainly using T implants, produced supra-physiological levels of T. The implications of this are considered further below.

In women with surgical menopause (i.e. bilateral ovariectomy), two contrasting studies will be considered. Sherwin et al. (1985) assessed women before undergoing hysterectomy and bilateral ovariectomy, and a 1 month baseline was established. Post-operatively, women were assigned to one of four treatment groups: E only, T only, E + T, or placebo, all given by monthly intramuscular injections for 3 months. This was followed by 1 month on placebo, and then a crossover to one of the other treatments. The T only and E + T treatments resulted in significantly higher levels of sexual interest, fantasy, and arousal than either E only or placebo. Mood was significantly better with all three hormonal regimes, and energy level and well-being were significantly better with the E + T and T regimes. These results relating to mood, energy, and well-being were published in two subsequent and separate papers (Sherwin and Gelfand, 1985a, 1985b) and we do not know to what extent these mood/energy changes were related to the sexual changes. This is the only study in which T administration on its own has been evaluated in post-ovariectomized women. The study is also noteworthy because it focused on the immediate post-operative period in women who were not experiencing sexual or mood problems pre-operatively.

In the other study to be considered, Shifren et al. (2000) recruited women who had had bilateral ovariectomy plus hysterectomy from one to 10 years previously. They were all experiencing impaired sexual function and all had been on E for at least 2 months before the study, and remained on the same dose throughout the study. The women were given transdermal T, with a daily dose of 150 µg or 300 µg, or placebo, each for 3 months in a randomized order. There was a substantial placebo response, but compared to placebo, the 300 µg T dose did have a significantly better effect on frequency of sexual activity and pleasure/orgasm (but not on sexual desire or arousal, as in the Sherwin et al. 1985 study). Since this study, there have been four further studies in this area, though using a parallel group rather than a cross-over design, and these have reported similar results (Braunstein et al., 2005; Buster et al., 2005; Davis et al., 2006; Simon et al., 2005). This series of studies shows a widespread tendency for authors reporting on data from pharmaceutical trials to report treatment effects as overall group means. It is therefore not possible to distinguish between a close to average response in most women in contrast with no response in some, and a more substantial response in others. This is of particular relevance to the topic of individual variability in women's sexuality, as we cannot use such studies to determine whether there are variations in response pattern which might fit into different sub-types of women's sexuality e.g., T-dependent versus non-T-dependent.

It is noteworthy that, in an Endocrine Society Clinical Practice Guideline on Androgen Therapy in Women (Wierman et al., 2006), there is a clear recommendation against making a diagnosis of androgen deficiency at this time "because there is neither a well-defined clinical syndrome nor normative data on testosterone or free testosterone levels in women across their lifespan that can be used to define the disorder" (p. 3699). There is no consideration in this report of the possibility that some women may be more dependent on T than others, and in its detailed review of the literature, the focus is on

average treatment effects that could obscure the existence of strong responders and non-responders.

Looking at the evidence across these different types of studies, what conclusions can we draw about the role of T in women's sexuality? There are enough positive indicators to conclude that T is relevant. But one possibility is that this relevance is confined to a sub-group of women; how large a sub-group or whether they are a majority remains unclear. The closest we can get to this is the estimate of around 50% from the study of ovariectomy by Nathorst-Böös et al. (1993a). Mainly derived from studies of the effects of OCs, is the idea of a threshold for T in women, much lower than the threshold for men, and in the lower part of the normal female range, below which women will experience signs of T deficiency, such as low sexual desire. This interesting possibility has to be reconciled with the evidence from studies of women given intramuscular T injections, where supra-physiological levels are associated with improvement. In men, increasing T levels above a critical threshold has little effect on sexuality. There are two points to keep in mind here; firstly, these pharmacological effects of high levels of T may depend on effects on mood and well-being, with secondary benefits to sexuality. This may in part result from the conversion of T to E that will be considered further below. Secondly, there is also evidence from these studies that desensitization results from these supra-physiological plasma levels, so that higher levels of T are then required to maintain the same benefits (Davis et al., 1995). It is crucially important to find out whether this desensitization is reversible, as this has a clear bearing on the long-term clinical use of T in women.

Estradiol

It is striking how much less research attention has been paid to the role of E in women's sexuality compared to T. There is a long-standing and reasonably well-supported assumption that E is necessary for normal vaginal lubrication. The post-menopausal reduction in E is commonly associated with vaginal dryness, which improves with E replacement (Rymer and Morris, 2000). However, pre-menopausal women not infrequently experience vaginal dryness (e.g., Bancroft et al., 2003a), and this is not likely to be due to insufficient E. Moreover, not all post-menopausal women with vaginal dryness find that E replacement solves the problem (Vestergaard et al., 2003). Whether E has a direct effect on sexual interest and sexual arousability is uncertain. There are few studies that have specifically aimed to address this question; below are two relatively early examples.

Dennerstein et al. (1980) studied 49 women who had been ovariectomized, all of whom had stable, satisfying sexual relationships. Using a double-blind, cross-over design, women spent 3 months on each of four hormone replacement regimes: (i) ethinylestradiol (EE); (ii) l-norgestrel (N), a progestogen; (iii) a combination of EE and N; (iv) placebo. The EE only regime was significantly better than the other three regimes in improving sexual interest, sexual enjoyment, orgasmic frequency, and mood. Noteworthy were correlations between measures of sexual desire and "feelings of well-being." It is possible that the sexual improvement was secondary to the mood improvement. Nathorst-Böös et al. (1993b), in a parallel group design, compared transdermal E (Estraderm® 50 µg daily) with placebo in naturally menopausal women seeking treatment for menopausal symptoms, who had not previously received hormone replacement. After 3 months, the E group reported significantly more sexual fantasies, better vaginal lubrication, less coital pain, and more sexual enjoyment. In this case, it is possible that the improvement in sexual fantasies and enjoyment was secondary to the improvement in vaginal lubrication. No study to date has systematically varied the dosage of E to see to what extent E effects are dose dependent.

A further factor that serves to obscure the roles of T and E in women's sexuality is the substantial amount of aromatization of T to E in the brain and the presence of both T and E receptors in the brain. Based on experimental data from rhesus monkeys, Wallen and

Parsons (1998) have proposed that the sexual effects of T in women are based on its conversion to E, and the increase in free E that T induces because of its competitive binding to SHBG. If they are correct, then this makes it more difficult to understand how some women might be more T dependent in their sexuality. However, the possibility that women vary in their sexual responsiveness to T remains a potential contributor to the variability of women's sexuality. We have more questions than answers in this difficult field.

Changes in women's sexuality across the lifespan

Graham et al. (2004), in their focus group study involving 80 women, aged 18–84 years, found some quite striking and potentially important age-related differences in the factors reported as enhancing and inhibiting sexual arousal. Younger women (18–24 years old) were more likely to cite partner-related themes as important influences on their sexual arousal e.g., partners' grooming, dress, and personality were frequent topics of discussion in the younger age groups. In contrast, themes in a category labeled "self" (e.g., mood, physical state) were more often raised by women in the older age groups.

In adult women, there are changes through the life span that may be associated with age, but not as clearly and consistently as is found with men. Hayes and Dennerstein (2005) reviewed 18 cross-sectional, community-based studies of women's sexuality, with ages ranging across the studies from 16 to 96. They concluded that sexual activities and sexual function declined with age, starting somewhere between the late twenties and late thirties. The number of women who remained sexually active and the frequency of sexual intercourse both declined in the older age groups.

In older age groups, the impact of having or not having a sexual partner is greater in women than in men. Older women are less likely than younger women to be distressed by low levels of sexual desire (Bancroft et al., 2003a; Hayes et al., 2007). Another factor is fertility; for some women, being fertile, even if they are not actively trying to conceive, gives their sexuality some justification. Such women may find that passing through the menopausal transition results in their having less interest in sex. In other women, loss of fertility may have a liberating effect on their sexuality. The mid-life period, for a variety of reasons, including the loss of fertility, may result in depression, and there is now evidence, consistent across studies, that one of the most important determinants of sexual well-being in women is good mental health (e.g., Bancroft et al., 2003a). If it proves to be the case that there are different sub-types of women's sexuality, then it would not be surprising if women who belong to these sub-types reacted differently to these lifespan transitions.

When we consider hormonal factors, another layer of complexity is added. A number of studies have reported that adrenal androgens (A and DHEA) show a decline with age over a relatively wide age span (e.g., Bancroft and Cawood, 1996; Burger et al., 2000; Davison et al., 2005). This was most convincingly shown in a study of ovariectomized women, in whom ovarian androgens could not complicate the picture (Crilley et al., 1979). Cross-sectional studies have reported a steady decline with age in T (both total and free T), with menopausal status having no influence on this decline (e.g., Davison et al., 2005; Zumoff et al., 1995). Longitudinal studies, on the other hand, have shown a somewhat different picture. In the Melbourne Women's Midlife Health Project, in which women were assessed regularly over the 7 years around the menopausal transition, total T did not change, whereas free T increased from pre- to post-menopause (Burger et al., 2000). In a more recent study from the Michigan Bone Health and Metabolism Study (Sowers et al., 2009), that assessed women over a 15-year period, total T increased with age, though leveling off after 50 years old. SHBG showed a general trend of reduction, but with a more marked decrease around the menopausal transition, consistent with the reduction in E at that time. The Free Androgen Index (FAI)

consequently showed a more marked increase following the final menstrual period.

Overall, uncertainties remain about the extent to which changes in sexuality are due to the menopausal transition rather than age. Some studies have found no evidence that menopausal status has an effect, others have found the opposite, and the reasons for these seemingly contradictory findings are as yet unclear (for a more detailed review, see Bancroft, 2009). It is also important to consider the possible effects of dyspareunia, induced by vaginal dryness, on sexual desire in post-menopausal women (Avis et al., 2009). Once again, the variability of women's sexuality may help to explain this inconsistency. Samples may vary in the proportion of different sub-types of women. Dennerstein and her colleagues conducted the Melbourne longitudinal study and have written extensively about the menopausal transition, emphasizing the importance of the associated hormonal changes. In one of their recent reports from this study, however, this emphasis was modified and the authors concluded that sexual function before the menopausal transition and relationship factors are more important than hormonal determinants of sexual function in mid-life (Dennerstein et al., 2005).

A proposed theoretical approach

Meana (2010), in her list of recommendations for future research on women's sexual desire, advised an atheoretical approach, arguing that "this type of open-ended strategy is likely to better capture the diversity of women's experiences" (p. 117). We disagree with her on this point. It is not difficult to demonstrate this diversity; it is more difficult and more important to capture it in a way that explains the variability. For this, testable theoretical models are required.

The dual control model

In our own research, we have been involved in a renewed focus on individual variability, a theme that Alfred Kinsey and his colleagues emphasized in their research 60 years ago. We first developed a theoretical model, called the Dual Control Model, which postulates that the psychobiological basis of our sexual responsiveness depends on the interaction between an excitatory system and an inhibitory system, and that individuals vary in their propensities for sexual excitation and sexual inhibition. We have subsequently developed psychometrically established questionnaires for assessing these individual propensities, which produce close to normal distributions of scores on both excitation and inhibition scales for men and women. Women show, on average, higher inhibition, and men higher excitation, although there is considerable overlap of the two genders (Bancroft et al., 2009; Graham et al., 2006; Janssen et al., 2002). This model has therefore provided clear evidence of variability of both propensities across women (Bancroft et al., 2009). With sexual excitation we can perhaps see this as variability in the intensity of sexual desire, or at least the capacity to be aroused by sexual stimuli. Future research may show us that women vary in the types of sexual stimuli that make them aroused in ways that may lead to meaningfully different sub-types. Similarly, the variability in total inhibition scores may conceal sub-types of women who differ in the type of inhibition that principally affects them. This difference may reflect the contrast between unconscious or automatic inhibition, such as that covered by the "arousal contingency" factor in the Sexual Excitation/Sexual Inhibition Inventory for Women (Sanders et al., 2008), and more conscious inhibition, as illustrated by "putting on the brakes" when the appraisal of the situation indicates that the risks are not worth taking, or the likely costs too high (Graham et al., 2004). Research using these measures to identify sub-groups has not yet started, but may prove to be informative.

Our new theoretical model—The basic patterns and “superadded” components

This model is based on what we regard as the fundamental characteristic of sex, reproduction. We realize that in some sexological circles it is considered inappropriate to focus on reproduction and recognize that in the human species, and to some extent in some of our primate relatives, sex has taken on a variety of functions that are not related to reproduction. We are also aware of the extent to which these non-reproductive functions have been socially constructed, and perhaps even more so, socially stigmatized and suppressed. But, for us, reproduction is definitely not a “social construct,” and is the starting point for understanding our varied sexualities.

The basic pattern

Thus we start with what we have called “the basic pattern,” and by this we mean the pattern that has evolved to ensure reproduction. We propose a male basic pattern and a female basic pattern, each of which is designed to facilitate a reproductive outcome. For the man, this involves having a sexual organ that, in states of sexual arousal, becomes erect and erotically highly sensitive, and responsive to appropriate stimulation. In some way, which we do not as yet fully understand, that appropriate stimulation becomes linked in the man's mind to another person who he sees as sexual attractive (usually this is a woman). By this time the man has probably learnt that inserting his erect penis into a woman's well-lubricated vagina is the ideal way for it to be stimulated. He tries to gain access and if his female partner allows it, he will probably ejaculate into her vagina, having enjoyed the experience considerably.

For the woman, there may be a very different agenda. She feels good if a man indicates that he finds her sexually attractive. If such a man is seeking her attention, she will go through some appraisal process, more or less explicit, to assess whether he is someone to be encouraged by her. Does she find him attractive? Does he seem responsible? Is this an appropriate time or place to allow this interaction to develop? In most respects, the woman is in control of this decision-making, and providing she feels in control she will find the unfolding sequence increasingly emotionally rewarding. Their physical contact may start with kissing or caressing. At some point, if it progresses typically, they will be undressed in a suitably private situation to allow further sexual contact. She will probably discover that when the time comes for the man to insert his erect penis into her vagina, she will be able to experience this without pain, and with her vagina suitably lubricated. As long as she feels able to say “stop” at any point if she needs to, she will continue to enjoy the unusual and intense intimacy of the experience. This may be a particularly powerful experience for her once the man is inside her and obviously enjoying it, and this does not depend on her experiencing sexual pleasure. In this context the evolution of an automatic pattern of vaginal lubrication and the associated specialized mechanisms for reducing or avoiding pain from vaginal penetration, considered earlier, begins to make sense.

These are descriptions of the male and female basic patterns, the man's experience being dominated by the pursuit of sexual pleasure, the woman's by a powerful sense of being desired, and a sense of emotional intimacy, both of which are very rewarding, made possible by her sense of being in control.

The super-added components

In both men and women there are other aspects of the experience which may be rewarding, but which are not necessary for reproduction. Thus the man may enjoy the emotional closeness, feeling wanted by the woman, or in some sense seeing the experience as formative for an ongoing relationship, similar to components of the female “basic pattern.” The woman may enjoy sexual pleasure from being touched, from having her anterior vaginal wall, or her clitoris

caressed, or she may enjoy having an orgasm, all of which are similar to fundamental components of the male “basic pattern.” As yet there is no evidence that any of these super-added components have any impact on a woman's fertility, apart from the indirect effect of motivating her for further sexual interaction. This fits with the limited evidence of variability of genetic determinants of these super-added components, discussed earlier.

This brings us back to the challenging issue of woman's sexual desire, also considered earlier. It can be desire for sexual pleasure. It may seem unreasonable to assume that not all women are interested in sexual pleasure. Yet the evidence suggests that some women are much more interested in obtaining sexual pleasure than others. This is manifested in masturbation, with some women starting this before puberty, clearly an activity aimed at pleasure, and derived independently of a woman's partner. Masturbation usually leads to orgasm, and here again we see considerable variability in the frequency with which women experience orgasm.

Sexual desire clearly varies considerably in strength and frequency across women. Here a T dependent sexual desire, comparable to that found in men, may be important in some women, and we have already considered the evidence suggesting a role for T in some women's sexuality. Both this T effect and the capacity for orgasm may reflect variable genetic dispositions, variable because in women they are not necessary for reproduction and can be considered “by-products” of basic male sexuality. However, there are other types of desire, and sex researchers are just starting to explore these. There can be desire to be desired, and desire for various aspects of sexual intimacy (Impett and Peplau, 2002; McCall and Meston, 2006; Meston and Buss, 2007). These can be seen as manifestations of the basic pattern. This variety of “sexual desires” may help us to understand the otherwise confusing picture in the literature of the varied determinants and predictors of loss of sexual desire in women in relation to age and to menopausal status.

An explanation for why this distinction between basic and super-added components has not been clearly recognized previously may be that the super-added components for women fit our general ideas of sexual pleasure, whereas their basic pattern is not so explicitly sexual. Conversely, the super-added components of men's experiences are less readily acknowledged because they are less explicitly sexual. However, all this becomes more relevant when we are trying to understand the variability of women's sexuality, which presents us with more of a challenge than men's sexual variability.

The basic pattern over time

According to this theoretical approach, the basic pattern for the woman should be relatively universal. However, it becomes more complex when we try to understand how this changes over time. The relatively simple, but highly relevant concept of the woman being in control is perhaps most evident, as well as relevant, early in a woman's sexual life. It has direct relevance to the establishment of sexual relationships. Perper (1985) described a courtship sequence that he observed when people were meeting and establishing a sexual contact in a singles bar in the United States. After initial conversation, he observed a relatively predictable sequence of steps, with some key points (what he termed “escalation points”), leading to a couple eventually going off together. His conclusion was that this process is principally under the woman's control. There is now a substantial literature on non-verbal courtship behaviors (reviewed by Moore, 2010). In a courtship sequence, each partner plays a role in influencing the other by signaling that the other's attempts are welcome. According to Seal et al. (2008), non-verbal behaviors, such as kissing or touching, contribute more to sexual interactions that are experienced as physically arousing and passionate. Verbal behaviors contribute more to emotional intimacy. Moore concluded that women are more responsible for the earlier stages of courtship, and men appear to orchestrate the final sequence leading to sexual activity.

To what extent does this singles bar scenario relate to the process of starting and establishing a more enduring sexual relationship? The assumption of our theoretical model is that basically the same principles apply, at least as far as sexual interaction is concerned. However, it seems likely that there will be change over time. It is uncertain how long the woman will feel rewarded by the man's desiring her. As she gets older, she may worry that he desires her less because she is becoming less attractive. The element of control perhaps becomes restricted to more bedroom-based interactions, with a wide range of other types of interactions comprising the couple's life outside the bedroom. But the general principles may well continue to be relevant.

Given that we are assuming that this pattern is fundamental to reproduction, the question also arises as to what happens when contraception is being used, and later, when the woman is post-menopausal and no longer fertile. The idea of a woman needing the possibility of conception to allow her to enjoy sex has been widely acknowledged, but this simple association is probably only relevant to a small minority of women. As discussed earlier, for other women, being freed from the risk of possible conception can have an enhancing and liberating effect on their sexual experience. It is, however, conceivable that a proportion of women, once they have lost their capacity for reproduction, either by the menopausal transition, or by hysterectomy, will feel differently about being sexual. If, on the other hand, they have well established "super-added components" they may continue to enjoy sex as a source of pleasure, or as a rewarding form of intimacy, and their sexual lives may continue much as before.

How testable is this theoretical approach? A sustained long-term research program will be needed. First, we need to establish markers of the female basic pattern, including the "desire to be desired" and the reward of being desired, but also the sense of needing to feel in control. These can be explored in young women to see how predictable and prevalent these markers are. Assuming that they would be found to be common, the next step would be to assess these same identifiers in women of older age groups to explore to what extent they may change with age and with the menopause.

For the superadded components, establishing the importance of orgasm in different age groups would be a starting point. The questions from a recent Kinsey Institute Survey (Bancroft et al., 2010), asking how important each of four consequences of sex were to a woman's sexual happiness, could be used. In this survey, the percentages of women considering a consequence as "very or extremely important" for their sexual happiness were 83.2% for "to feel emotionally close to your partner," 78.2% for "that your partner be sexually satisfied," 60.9% for "to feel comfortable talking to your partner about sex," and 29.1% for "to have an orgasm." It would be interesting to study women who regard orgasm as very important and explore how they differ in other ways from women who perceive orgasm as less important. Further questions of this kind could be developed.

Recent research on cues resulting in desire for sexual activity in women may provide highly relevant questions for this purpose. McCall and Meston (2006) explored a large variety of potential cues and ended up with four factors, each with 10 items. Three of the factors may be more relevant to our basic pattern: emotional bonding cues (e.g., experiencing emotional closeness with a partner); romantic/implicit cues (e.g., dancing closely); and visual/proximity cues (e.g., talking with someone famous). The fourth factor, explicit/erotic cues (e.g., watching an erotic movie) may be more relevant to the superadded components.

Development of the research paradigm used by Sand and Fisher (2007) may also prove helpful. A sample of 133 nurses were presented with brief descriptions of the Masters and Johnson (1966), Kaplan (1979), and Basson (2000) models of sexual response and asked to indicate which, if any of them, accurately reflected their

own sexual experience. They also completed the Female Sexual Function Index (FSFI; Rosen et al., 2000). Approximately equal proportions of women endorsed each of the three models as representing their own sexual experiences. Women endorsing the Basson model had significantly lower FSFI scores (suggestive of problems with sexual functioning). A more recent study (Giles and McCabe, 2009) supported these findings, indicating that Basson's model may fit the experiences of women with sexual problems better than that of women without sexual problems. These studies utilized a potentially valuable methodology for identifying different varieties of women's sexuality, which could be developed and used to test our theoretical model. Narratives describing sequences which fit the basic pattern can be compared with those which fit the superadded component. Women could then be asked to select those which best fit their own experiences. This could also be done retrospectively, so that participants could be asked to also select those models best fitting their early sexual experiences.

Research is needed to identify markers of women who are T dependent in their sexuality. Here, as with orgasm, we are dealing with a variant of women's sexuality that is biologically and possibly genetically determined. There has recently been attention paid to the 2D:4D finger digit ratio, which is typically closer to one in females, with males having a smaller 2D:4D ratio. There is evidence that this may be a manifestation of earlier exposure to androgens, and that women with a relatively lower ratio may have had more early exposure to androgens which may have desensitized them to T. Oinonen (2009) has recently shown that low 2D:4D in women is associated with more emotional and sexual side effects from OCs, presumably resulting from the OC-induced reduction in T. We should be looking for other potential markers of T sensitivity in terms of sexual history e.g., early onset of masturbation and orgasm.

The assumption of our model is that the large majority of women will show some evidence of the basic pattern, and smaller proportions will also show evidence of one or more of the super-added components. Once we have a better understanding of these "normal" varieties of women's sexuality, we will be in a much better position to understand how they can go wrong.

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